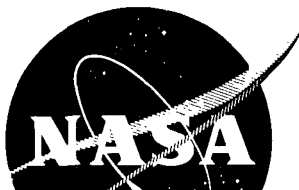


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# THE NASA EARTH RESOURCES SPECTRAL INFORMATION SYSTEM: A DATA COMPILATION

## First Supplement

by  
V. Leeman

INFRARED AND OPTICS LABORATORY  
WILLOW RUN LABORATORIES  
INSTITUTE OF SCIENCE AND TECHNOLOGY  
THE UNIVERSITY OF MICHIGAN



prepared for

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**TECHNICAL REPORT**

**THE NASA EARTH RESOURCES SPECTRAL INFORMATION SYSTEM  
A DATA COMPILATION**

**First Supplement**

by  
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INFRARED AND OPTICS LABORATORY  
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March 1972

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NASA Manned Spacecraft Center  
Earth Observations Division  
Houston, Texas 77058

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### FOREWORD

This report describes part of a comprehensive and continuing program of research into remote sensing of the environment from aircraft and satellites. The research is being carried out by the Willow Run Laboratories, a unit of The University of Michigan's Institute of Science and Technology, for the NASA Manned Spacecraft Center, Houston, Texas. The basic objective of this multidisciplinary program is to develop remote sensing as a practical tool to provide the planner and decision-maker with extensive information quickly and economically.

Timely information from remote sensing will be important to such people as the farmer, the city planner, the conservationist, and others concerned with a variety of resource problems such as crop yield and disease, urban land studies and development, air and water pollution, and forest and rangeland management. The scope of our program includes: (1) extending understanding of basic processes affecting the content and cost of the information; (2) developing new applications, advanced remote sensing systems, better automatic data processing to extract information in a useful form; and (3) assisting in data collection, processing, and analysis, including laboratory and field material spectra and ground-truth verification.

The research described herein was performed under NASA Contract NAS 9-9784 and covers the period 1 October 1970 through 1 November 1971. The program is directed by R. R. Legault, Associate Director of Willow Run Laboratories, and J. D. Erickson, Principal Investigator. The work was done under the management of the Earth Observations Division, Manned Spacecraft Center. The Willow Run Laboratories' number of this report is 31650-69-T. Reports issued by the Infrared and Optics Laboratory on related programs are listed in Appendix II.

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#### **ACKNOWLEDGMENTS**

The author wishes to acknowledge the assistance of R. Vincent, S. Ladd, M. Schall, J. Wright, and K. Bohms in the preparation of this report.

### ABSTRACT

This report describes the NASA Earth Resources Spectral Information System (ERSIS) and the information contained therein. It is intended to be used as a supplement to the "NASA Earth Resources Spectral Information System: A Data Compilation," NASA CR-31650-24-T, May 1971.

This supplement includes approximately 500 rock and mineral, 100 soil, and 30 vegetation bidirectional and directional reflectance, transmittance, emittance, and degree-of-polarization curves in the optical region from 0.2 to 22.0  $\mu\text{m}$ . The data have been categorized by subject and each curve plotted on a single graph. For some rocks and minerals, all curves of the same type, differing only in particle size, have been plotted on one grid as a composite plot. Each graph, composite or single, is fully titled to indicate curve source and is indexed by subject to facilitate user retrieval.

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# **THE NASA EARTH RESOURCES SPECTRAL INFORMATION SYSTEM: A DATA COMPILATION First Supplement**

## **SUMMARY**

This report summarizes the NASA Earth Resources Spectral Information System (ERSIS) and the information contained therein. It is intended to be used as a supplement to the "NASA Earth Resources Spectral Information System: A Data Compilation," NASA CR-31650-24-T, May 1971.

This supplement contains approximately 500 rock and mineral, 100 soil, and 30 vegetation bidirectional and directional reflectance, transmittance, emittance, and degree-of-polarization curves in the optical region from 0.2 to 22.0  $\mu\text{m}$ . The data have been categorized by subject and each curve plotted on a single graph. For some rocks and minerals, all curves of the same type, differing only in particle size, have been plotted on one graph as a composite plot. Each graph, composite or single, is fully titled to indicate curve source and is indexed by subject to facilitate user retrieval. In addition, the documents from which the curves have been extracted are summarized to facilitate data use. Information on the experimental platform, instrumentation, reflectance standards (for relative data), and other related matters has been included, and additional references describing some of the instrumentation in greater detail are cited.

All of the data included in this publication are available in digital form at NASA/MSC as part of the ERSIS. The present computer facility includes a set of magnetic tapes containing the optical spectral data and a series of computer programs for updating the magnetic tapes, for retrieving data from the tapes, and for analyzing the retrieved data.

# 1

## INTRODUCTION

The Earth Resources Spectral Information System (ERSIS) established at NASA/MSU in 1970 and maintained by The University of Michigan is intended to provide the spectral signatures of natural targets to scientists in the remote sensing community in a catalogue form which is simple to use. The current ERSIS consists of a set of magnetic tapes containing optical spectral data and a series of computer programs for updating these magnetic tapes, for retrieving data from the tapes, and for analyzing the retrieved data. Sources for the data are reports published by laboratories making such measurements and unpublished data acquired directly from an experimenter.

All of the data incorporated into the ERSIS during its first year were published in graphical form in a technical report in 1971 [1]. That report contains approximately 100 rock and mineral, 2600 vegetation, 1000 soil, and 60 water spectra. This first supplement includes nearly 500 rock and mineral, 100 soil, and 30 vegetation spectra which were added to the ERSIS this year. The choice of data added was influenced by the data gaps pointed out in one of our reports of last year [2]. These new curves particularly help fill the data gap existing for visible and reflected infrared spectra of rocks and minerals. Recent measurements of soils and vegetation have also been added to update and broaden these categories.

Each data curve in this publication has been assigned alphabetic and/or numeric descriptor codes to describe the object measured. A list of these codes is given in Section 2. The data curves have been grouped according to the coded descriptor that best describes the object measured. This prime descriptor, a page number, and the common names of the objects are arranged as a cross index in Section 3.

Section 4 contains the plots of bidirectional and directional reflectance, transmittance, emittance, and degree-of-polarization curves. The plots are grouped according to the subject codes presented in Section 2 and arranged in the following order: soils, vegetation, and rocks and minerals. For some rocks and minerals, all curves of the same type, differing only in particle size, have been plotted on one grid as composite plot; all other curves appear as single plots. Included with each plot, composite or single, is a title listing of the material measured, plus the curve and document numbers which completely identify the curve source.

Appendix I of this report discusses the documents from which the data were obtained and the curve identification numbering system. Appendix II contains a list of related reports. The reader is strongly advised to inspect the original volume of this publication [1] for more data and for additional information about reflectance theory and the standard instrumentation procedures used to collect the data. The general areas in which additional spectra are needed are called out in Ref. [2]. Four examples of the types of analyses made possible by a collection of ERSIS spectra are given in Ref. [3]. A description of the techniques and software used for

processing, retrieval, and routine analysis of ERSIS data is detailed in Ref. [4]. In addition to these reports, published in 1971, there are three current ERSIS reports, companions of this supplement, which should be useful to ERSIS users. One, entitled "NASA/MSC Earth Resources Spectral Information System Procedures Manual, Supplement," by V. Leeman [5], is the updated version of Ref. [4]. Another is a technical report entitled "Rock-Type Dissemination from Ratio Images of the Písgah Crater, California Test Site," by R. Vincent [6], which describes the application of ratio method devised last year [3] to an arid, rocky terrain. Finally, another technical report by R. Vincent, G. Suits, H. Horowitz, and P. Hyde, entitled "Investigation of the Theoretical Methods for the Optical Modeling of Agricultural Fields," [7] gives the results of a study on the problem of linking laboratory spectra with radiation detected by an airborne scanner for agricultural applications.

## 2

### LIST OF SUBJECT CODES

Those agency investigators and scientists interested in using the ERSIS probably will have useful suggestions for improving the classification schemes and subject codes, and these will be welcome. As more data are added to the ERSIS, more detailed breakdowns and codes will be required. The numbers shown in parentheses correspond to the number of spectra for each category. Numbers adjacent to the major subject-code categories indicate the number of curves included which do not fit into any of the subcategories under that major subject code. All numbers indicate the total number of curves in the ERSIS and not necessarily only those in this publication.

#### 2.1. SOIL AND WATER SUBJECT CODES

Table 1 contains a list of alphabetic soil and water subject codes. The soils are classified according to texture and soil series, and the water spectra are arranged according to macroscopic formation and physical state.

#### 2.2. VEGETATION SUBJECT CODES

The alphabetic vegetation subject codes, classified according to biological families, are listed in Table 2. In Table 3, entitled "Supplement to Vegetation Subject Codes," the vegetation spectra are classified with alpha-numeric codes using layman nomenclature for the plant families. Every vegetation curve has been classified with two subject codes: one for the biological names, and one for the common name. From these two tables, one can select curves of individual species or of entire plant families.

#### 2.3. ROCK AND MINERAL SUBJECT CODES

The large quantity of rocks and minerals added to the ERSIS this year resulted in the expansion and reorganization of the rock and mineral subject codes for this supplement.

TABLE 1. SOIL AND WATER SUBJECT CODES  
(Classified according to texture and series)

BE	Terrain Uniformity (213)	BFIN	Dublin (3)
BEA	Flat (21)	BFIO	Gooch (3)
BEB	Rolling	BFIP	Grady (3)
BEC	Hilly (4)	BFIQ	Greenville (4)
BED	Mountainous (38)	BFIR	Guthrie (2)
BEE	Rural (112)	BFIS	Hainamanu (1)
BEF	Urban	BFIT	Hall (2)
BF	Soil (90)	BFIU	Hamakua (2)
BFA	Cultivated (27)	BFIV	Herradura (2)
BFB	Uncultivated	BFIW	Joplin (2)
BFC	Coarse Textured	BFIX	Marias (2)
BFCA	Sand (122)	BFIY	Marshall (2)
BFCB	Loamy Sand (6)	BFIZ	Matanzas (2)
BFD	Moderately Coarse Textured (1)	BFJ	Series (Continued)
BFDA	Sandy Loam (30)	BFJA	Maury (3)
BFDB	Fine Sandy Loam (20)	BFJB	Moaula (4)
BFE	Medium Textured	BFJC	Naalehu (4)
BFEA	Loam (28)	BFJD	Onomea (2)
BFEB	Silt Loam (25)	BFJE	Ookala (4)
BFEC	Silt (3)	BFJF	Orangeburg (4)
BFF	Moderately Fine Textured	BFJG	Oriente (2)
BFFA	Clay Loam (22)	BFJH	Orman (2)
BFFB	Sandy Clay Loam	BFJI	Pallman
BFFC	Silty Clay Loam	BFJJ	Penn (2)
BFG	Fine Textured	BFJK	Pierre (2)
BFGA	Sandy Clay	BFJL	Putnam (2)
BFGB	Silty Clay	BFJM	Quibdo (2)
BFGC	Clay (42)	BFJN	Rubicon (2)
BFH	Other Constituents (13)	BFJO	Ruston (8)
BFHA	Organic Material (3)	BFJP	Santa Barbara (4)
BFHB	Gravel (less than 3-in. diameter) (7)	BFJQ	Texas Dune (2)
BFHC	Cobbles (3- to 10-in. diameter) (6)	BFJR	Tifton (2)
BFHD	Stones (greater than 10-in. diameter) (10)	BFJS	Tillman (2)
BFHF	Salt (1)	BFJT	Tilsit (2)
BFI	Series	BFJU	Vernon (2)
BFIA	Aguan (2)	BFJV	Weld (4)
BFIB	Aiken (2)	BFJW	Windthorst (4)
BFIC	Akron (2)	BFJX	Yolo
BFID	Alamance (2)	BFJY	Zanesville (2)
BFIE	Albion (2)	BFK	Minerals (22)
BFIF	Alonso (2)	BFL	Chemicals (14)
BFIG	Barnes (3)	BH	Water (2)
BFIH	Blakely (4)	BHA	Formations (2)
BFII	Clareville (2)	BHAA	Lake (6)
BFIJ	Clarion (2)	BHAB	Puddle
BFIK	Collington (1)	BHAC	River (4)
BFIL	Colts Neck (9)	BHAD	Sea (12)
BFIM	Decatur (2)	BHB	State
		BHBA	Ice
		BHBB	Ice and Liquid
		BHBC	Liquid (8)
		BHBD	Snow (29)

TABLE 2. VEGETATION SUBJECT CODES  
(Classified according to families in a biological sense, e.g., Mustard Family)

BG	Vegetation (31)	BGCM	Selin (1)
BGA	Herbaceous, Algae Fungi	BGCMN	Timothy (9)
BGAA	Cladoniaceae Family (1)	BGCMO	Vetch (1)
BGAAA	Reindeer Moss (3)	BGCMF	Wheat (140)
BGB	Moss-Liverwort (6)	BGCN	Heath Family (5) (see also Ligneous)
BGBA	Sphagnum Family		European Blueberry
BGBAA	Sphagnum Moss (1)	BGCNA	Heather (1)
BGC	Vascular (5)	BGCNB	Mallow Family
BGCA	Banana Family (2)	BGCO	Cotton (121)
BGCAA	Banana	BGCOA	Mustard Family
BGCB	Bromeliaceae Family	BGCP	Cabbage (5)
BGCB	Bunch Grass (1)	BGCPA	Mustard (1)
BGCC	Buckwheat Family	BGCPB	Nightshade Family
BGCCA	Buckwheat (1)	BGCQ	Potatoes (5)
BGCD	Composite Family (2)	BGCQA	Tomatoes (4)
	(cf. Ligneous)	BGCQB	Pea (or Pulse) Family (3)
BGCDA	Daisy (3)	BGCR	(see also Ligneous)
BGCDB	Goldenrod (1)		Alfalfa (32)
BGCDC	Ragweed (3)	BGCRA	Clover (8)
BGCDD	Sunflower (1)	BGCRB	Coffee Plant (1)
BGCE	Convolvulus Family	BGCRC	Lentil (2)
BGCEA	Sweet Potato (1)	BGCRD	Lima Bean (3)
BGCF	Crowfoot Family	BGCRE	Pea (1)
BGCF	Crowfoot (3)	BGCRF	Peanut (9)
BGCG	Duckweed Family	BGCRG	Soybean (158)
BGCGA	Duckweed (2)	BGCRH	String Bean (4)
BGCH	Evening-Primrose Family	BGCRI	Plantain Family
BGCHA	Willow Herb (cf. Willow Family) (1)	BGCS	Plantain (2)
BGCI	Fern Family (3)	BGCSA	Sedge Family (1)
BGCIA	Bracken Fern (1)	BGCT	Cotton Grass (1)
BGCJ	Flax Family	BGCTA	Sedge (5)
BGCJA	Flax (5)	BGCTB	Ligneous (24)
BGCK	Goosefoot Family (3)	BGD	Arecaceae Family (7)
BGCKA	Pigweed (3)	BGDA	Areca Palm (3)
BGCKB	Sugar Beet (9)	BGDAA	Beech Family
BGCL	Gourd Family	BGDB	Beech (24)
BGCLA	Squash (3)	BGDBA	Chestnut (2)
BGCM	Grass Family (136)	BGDBB	Oak (160)
BGCM	Barley (15)	BGDBC	Bignonia Family
BGCMB	Bermuda Grass (1)	BGDC	Catalpa (12)
BGCMC	Corn (188)	BGDCA	Dalycanthaceae Family
BGCMD	Creeping Grass (1)	BGDD	Meratia Praecox (2)
BGCME	Fescue (3)	BGDDA	Carduacea Family
BGCMF	Foxtail (6)	BGDE	Rabbit Brush (1)
BGCMG	Ilyas (13)	BGDEA	Cashew Family
BGCMH	Millet (4)	BGDF	Chinese Pistachio (1)
BGCM	Oats (15)	BGDF	Sumach (2)
BGCMJ	Reeds (1)	BGDFB	Composite Family (2) (cf. Herbaceous)
BGCMK	Rice (5)	BGDG	Sagebrush (3)
BGCM	Rye (7)	BGDGA	Wormwood (3)
		BGDGB	

BGDH	Dogwood Family	BGDXE	Pine (211)
BGDHA	Dogwood (35)	BGDXF	Spruce (11)
BGDI	Ebony Family	BGDY	Plane-Tree Family
BGDIA	Ironwood (2) (cf. Hazel Family)	BGDYA	Sycamore (150)
		BGDZ	Pea Family (5) (cf. Herbaceous)
BGDIB	Persimmon (2)		Locust (4)
BGDJ	Elm Family	BGDZA	Ligneous (continued)
BGDJA	Elm (23)	BGE	Rose Family (16)
BGDK	Figwort Family (4)	BGEA	Blackberry (1)
BGDKA	Paulowina (1)	BGEAA	Cherry (9)
BGDL	Hazel Family	BGEAB	Hawthorn (1)
BGDLA	Alder (1)	BGEAC	Juneberry (3)
BGDLB	Birch (23)	BGEAD	Peach (10)
BGDLC	Hazelnut (6)	BGEAE	Pin Cherry (1)
BGDL D	Hornbeam (1)	BGEAF	Plum (11)
BGDLE	Ironwood (cf. Ebony Family)	BGEAG	Sour Gum Family (2)
		BGEB	Gum
BGDM	Heath Family (12) (cf. Herbaceous)	BGEBA	Trumpet-Creeper Family
		BGEC	Calabash (1)
BGDMA	Mountain Laurel (3)	BGECA	Vine Family
BGDN	Holly Family	BGED	Virginia Creeper (3)
BGDNA	Holly (3)	BGEDA	Walnut Family (1)
BGDO	Honeysuckle Family (2)	BGEE	Hickory (5)
BGDOA	Viburnum	BGEEA	Willow Family (100)
BGDP	Laurel Family (5)	BGEF	Aspen (36)
BGDPA	Laurel (2)	BGEFA	Poplar (113)
BGDPB	Sassafrass (3)	BGEFB	Willow (6) (cf. Evening Primrose Family)
BGDQ	Lily Family (2)	BGEFC	Dwarf (2)
BGDQA	Yucca (1)		Ground (1)
BGDR	Linden Family	BGEFCA	Witch Hazel Family
BGDRA	Basswood (54)	BGEFCB	Sweet Gum (52)
BGDRB	Linden (3)	BGEG	Leaf (138)
BGDS	Logania Family	BGE GA	Narrow (402)
BGDSA	Privet (2) (Ligustrum)	BGF	Broad (197)
BGDT	Magnolia Family (2)	BGFA	Coriaceous (Leathery)
BGDTA	Magnolia (4)	BGFB	Membranous
BGDTB	Tulip (2)	BGFBA	Lower Leaf Surface (478)
BGDT C	Tulip Poplar (5)	BGFBB	Upper Leaf Surface (564)
BGDU	Maple Family (168)	BGFBC	Young (Spring) (89)
BGDUA	Maple		Mature (Summer) (56)
BGDV	Mulberry Family (2)	BGFBD	Old (Fall) (114)
BGDVA	Rubber (10)		Dry (157)
BGDW	Olive Family (7)	BGFC	Bark (38)
BGDWA	Ash (58)	BGFD	Twig (21)
BGD X	Pine Family (6)	BGFE	
BGDXA	Cedar (8)	BGFF	
BGDXB	Fir (11)	BGG	
BGDXC	Juniper (6)	BGH	
BGDXD	Larch (4)		

TABLE 3. SUPPLEMENT TO VEGETATION SUBJECT CODES  
(Classified according to families in a layman, user-oriented  
sense, e.g., Crops)

40 Herbs (1)	44 Flowering weeds (22)
41 Crops (2)	44A Clover (8)
41A Vegetables (47)	50 Shrubs (44)
41A1 Soybeans (11)	51 Dogwood (35)
41A1A Soybean leaf, green (48)	60 Trees (7)
41A1B Soybean pods and stems (46)	61 Deciduous (49)
41A1C Soybean leaf, mature (11)	61A Nut trees (4)
41A1D Soybeans, flowering (30)	61A1 Hickory leaf (5)
41A1E Soybeans, seedling stage (12)	61A2 Hazelnut leaf (6)
41B Grains (17)	61A3 Nutree bark (2)
41B1 Barley (9)	61A4 Chestnut leaf (2)
41B1A Barley field, stubble (6)	61B Fruit trees (58)
41B2 Corn (23)	61B1 Plum fruit (3)
41B2A Corn leaf, green (47)	61B1A Plum leaf (7)
41B2B Corn leaf, brown (45)	61B1B Plum, bark and twig (5)
41B2C Corn leaf, yellow (15)	61C Ash (58)
41B2D Corn tassel (12)	61D Aspen (37)
41B2E Corn, normal stand (20)	61E Basswood (54)
41B2F Corn kernel (6)	61F Beech (24)
41B2G Corn, multicolored leaves (21)	61G Birch (23)
41B3 Oats (7)	61H Catalpa (12)
41B3A Oats field, stubble (9)	61I Elm (23)
41B4 Sorghum leaf, green (22)	61J Maple (45)
41B4A Sorghum, brown (15)	61J1 Silver maple (102)
41B5 Wheat (25)	61J2 Red maple (21)
41B5A Wheat field, normal stand (41)	61K Oak (45)
41B5B Wheat field, thin stand (35)	61K1 White Oak (47)
41B5C Wheat, diseased (13)	61K2 Black Oak (35)
41B5D Wheat heads (6)	61K3 Burr Oak (32)
41B5E Wheat, seedling stage (20)	61L Poplar (13)
41C Clothing fibers (5)	61L1 Cottonwood (97)
41C1 Cotton (121)	61M Sweet gum (52)
42 Nonflowering plants and weeds (60)	61N Sycamore (154)
42A Grass (50)	61O Tulip tree (or Yellow or Tulip poplar) (112)
42A1 Diseased grass (10)	61P Willows (8)
42A2 Brown grass (59)	62 Coniferous (37)
42B Ilyas (13)	62A Pine (19)
43 Flowering plants (36)	62A1 Red (or Norway) pine (118)
43A Alfalfa (32)	62A2 Scotch pine (68)
	62B Spruce (10)
	62B1 Spruce bark (1)

Table 4 lists the rock and mineral subject codes (alpha-numeric) classified according to rock and mineral composition. The codes are as detailed as is possible from the identifications reported and this variance in amount of detail results in some unevenness in the classification scheme. The silicate rocks are arranged approximately according to  $\text{SiO}_2$  content.

TABLE 4. ROCK AND MINERAL SUBJECT CODES  
(Classified according to basic, acidic content)

100 Igneous Rocks	103C Pyroxenite (1)
101 Acidic (Generally greater than 65% $\text{SiO}_2$ ) Silicate Rocks (1)	103D Diabase (2)
101B Obsidian (5)	103E Monchiquite (1)
101C Pumice (8)	103F Peridotite (5)
101D Tuff (7)	103L Serpentine (1)
101E Tektite (same as 142) (1)	103M Limburgite (1)
101F Quartz Monzonite (4)	103N Dunite (8)
101G Dacite (1)	103P Lava (5)
101H Granite (3)	110 Sedimentary and Metamorphic Rocks (2)
101H1 Graphitic Granite (1)	111 Silicate Sedimentary and Metamorphic Rocks (2)
101H2 Granite Gneiss (2)	111A Sandstone (1)
101H3 Potash Granite (1)	111A1 Yellow Sandstone (2)
101J Aplite (1)	111A2 Red Sandstone (2)
101J1 Granite Aplite (1)	111A3 Grey Sandstone (1)
101J2 Pyroxene Aplite (1)	111B Schist (1)
101L Rhyolite (22)	111F Shale (2)
101N Trachyte (1)	111H Siltstone (4)
101Q Migmatite (2)	111J Chert (3)
101R Adamellite (8)	111K Quartzite (2)
101T Felsite (3)	112 Carbonate Sedimentary and Metamorphic Rocks (2)
101U Pegmatite (4)	112A Limestone (13)
102 Intermediate (Generally 53% to 65% $\text{SiO}_2$ ) Silicate Rocks	112B Coral (2)
102A Syenite (1)	112C Dolomite (same as 123A1) (1)
102A1 Quartz Syenite (1)	112D Marble (1)
102A2 Nepheline Syenite (1)	120 Minerals
102B Andesite (21)	121 Silicate Minerals (Associated primarily with Acidic Rocks)
102B1 Hypersthene Andesite (2)	121A Quartz (44)
102B2 Hypersthene Andesite Vitrophyre	121B K-Feldspar (Orthoclase) (9)
102B3 Biotite Andesite Flow (2)	121C Grey Feldspar (Plagioclase) (21)
102D Basalt (Intermediate) (1)	121D Light-Colored Micas (3)
102G Diorite (8)	121E Clay minerals (Product of Weathering) (14)
102G1 Augitediorite (1)	122 Ferromagnesian Minerals (Associated primarily with Basic Rocks)
102I Latite (30)	122A Biotite and Phlogopite (3)
102P Grandiorite (2)	122B Olivines (13)
103 Basic and Ultrabasic (Generally less than 58% $\text{SiO}_2$ ) Silicate Rocks (2)	122C Pyroxenes (19)
103A Gabbro (5)	122D Amphiboles (28)
103A1 Garnet Gabbro (1)	122E Chlorites (Product of Weathering) (7)
103A2 Augite Gabbro (1)	122F Serpentine (Alteration Product) (4)
103A3 Olivine Gabbro (1)	122G Talc (Alteration Product) (4)
103A4 Hornblende Gabbro (2)	
103B Basalt (Basic and Ultrabasic) (18)	
103B1 Plagioclase Basalt (1)	



- 123 Accessary Minerals (7)
  - 123A Carbonate Minerals (4)
    - 123A1 Calcium-Magnesium Carbonate (Dolomite) (Same as 112C) (9)
    - 123A2 Magnesium Carbonate (Magnesite) (8)
    - 123A3 Calcium Carbonate (Calcite Limestone) (10)
    - 123A4 Sodium Carbonate (2)
    - 123A5 Copper Carbonate (Azurite, Malachite) (8)
    - 123A6 Manganese Carbonate (Rhodochrosite) (3)
    - 123A7 Iron Carbonate (Siderite) (4)
    - 123A8 Zinc Carbonate (Smithsonite) (2)
    - 123A9 Strontium Carbonate (Strontianite) (2)
    - 123A10 Barium Carbonate (Witherite) (3)
  - 123B Sulphur, Sulfate and Sulfide Minerals (1)
    - 123B1 Sulphur (4)
    - 123B2 Calcium Sulfates and Sulfides (Gypsum, Anhydrite Sand) (25)
    - 123B3 Aluminum Sulfates and Sulfides (Alunite) (4)
    - 123B4 Barium Sulfates and Sulfides (Barite) (4)
    - 123B5 Strontium Sulfates and Sulfides (Celestite) (4)
    - 123B6 Sodium Sulfates and Sulfides (Thenardite) (4)
    - 123B7 Iron Sulfates and Sulfides (Pyrite, Pyrrhotite, Jarosite, Arsenopyrite, Chalcopyrite, Jamesonite, Marcasite) (26)
    - 123B8 Arsenic Sulfates and Sulfides (Realgar, Arsenopyrite, Enargite, Niccolite, Proustite, Cobaltite) (21)
    - 123B9 Potassium Sulfates and Sulfides (Alunite, Jarosite) (5)
    - 123B10 Copper Sulfates and Sulfides (Chalcocite, Chalcopyrite, Enargite) (13)
    - 123B11 Mercury Sulfates and Sulfides (Cinnabar) (3)
    - 123B12 Cobalt Sulfates and Sulfides (Cobaltite) (4)
    - 123B13 Lead Sulfates and Sulfides (Galena, Jamesonite) (7)
    - 123B14 Antimony Sulfates and Sulfides (Stibnite, Jamesonite, Pyrargyrite) (11)
    - 123B15 Molybdenum Sulfates and Sulfides (Molybdenite) (3)
    - 123B16 Nickel Sulfates and Sulfides (Niccolite) (3)
    - 123B17 Silver Sulfates and Sulfides (Proustite, Pyrargyrite) (6)
    - 123B18 Zinc Sulfates and Sulfides (Sphalerite) (2)
  - 123C Nitrate and Nitrite Minerals
    - 123C1 Sodium Nitrates and Nitrites (2)
    - 123C2 Potassium Nitrates and Nitrites (2)
  - 123D Phosphate Minerals
  - 123E Carbonaceous Minerals
    - 123E1 Silicon Carbide (4)
    - 123E2 Graphite (1)
    - 123E3 Peat and Coal (1)
  - 123F Oxides and Hydroxides
    - 123F1 Iron Ox. and Hydrox. (Limonite, Hematite, Goethite, Magnetite, Ilmenite) (25)
    - 123F2 Manganese Ox. and Hydrox. (Psilomelane, Pyrolusite) (10)
    - 123F3 Titanium Ox. and Hydrox. (Rutile, Ilmenite) (9)
    - 123F4 Zinc Ox. and Hydrox. (Zincite) (4)
    - 123F5 Aluminum Ox. and Hydrox. (Corrundum and Artificial Ruby, Diaspore, Gibbsite, Chrysoberyl) (18)
    - 123F6 Beryllium Ox. and Hydrox. (Chrysoberyl) (4)
    - 123F7 Copper Ox. and Hydrox. (Cuprite) (3)
    - 123F8 Tin Ox. and Hydrox. (Cassiterite) (4)
    - 123F9 Magnesium Ox. and Hydrox. (Brucite) (4)
  - 123G Halides
- 124 Minor Silicate Minerals (23)
- 130 Ores and Hydrothermally Altered Rock
  - 131 Ores (2)
    - 131A Uranium Ore (1)
  - 132 Hydrothermally Altered Rock (5)
    - 132A Latite (Hydrothermally Altered) (2)
- 140 Meteorites
  - 141 Chondrites
    - 141A Leedy (2)
    - 141B Farmington (2)
  - 142 Tektites (Same as 101E) (1)

### 3 SUBJECT INDEX

To facilitate use of the data found in Section 4, an index by the common names of the materials published in this supplement appears below. The index has been divided into three main categories: rocks and minerals, soils, and vegetation. If one desires all the data on limonite, he would look under Rocks and Minerals for Limonite and find:

Limonite. . . . . 123F: 1, 2, 5

He would then proceed to the published data on Rocks and Minerals and scan the dividers for subject code 123F. The pages of data will be numbered, for example, 123F: 1, 123F: 2, and 123F: 5.

<b>Soils</b>		<b>Pumice</b>	101: 1, 6-8
Clay	BFGC: 1-7	Pyroxenite	103: 4
Humus	BFHA: 1	Quartz Monzonite	101: 5, 7
Loam	BFEA: 1	Quartzite	111: 1
Miscellaneous	BF: 1-9	Rhyolite	101: 1-3, 6-8, 10-12
Sand		Sandstone	111: 1
Carbonate	BFCA: 9, 10	Skarn	112: 1
Gypsum	BFCA: 5, 9, 10	Tuff	101: 4, 6
Quartz	BFCA: 1-11	<b>Minerals</b>	
Quartz and Calcite	BFCA: 5, 6	Alunite	123B: 1
Quartz and Carbonate	BFCA: 8, 9	Amphibole	122: 1, 2
Rhyolitic Beach Sand	101: 3, 8	Andalusite	124: 1
Silt	BFEC: 1	Anorthoclase Feldspar	121: 1
<b>Vegetation</b>		Arsenopyrite	123B: 1
Clover	BGCRB: 1	Azurite	123A: 1
Cotton	BGCOA: 1-7	Barite	123B: 1
Grass	BGCM: 1	Beryl	124: 1
Pine	BGDX: 1	Biotite	101: 11, 12; 122: 2
<b>Rocks and Minerals</b>		Brucite	123F: 2
<b>Rocks</b>		Calcite	123A: 1
Andesite	102: 1-5	Cassiterite	123F: 2
Basalt	103: 1-3, 5, 6	Celestite	123B: 1
Brecchia	132: 1	Chabazite	124: 1
Calcarenite	112: 1	Chalcocite	123B: 2
Diorite	102: 2-4	Chalcopyrite	123B: 2
Dolomite	123A: 1, 2	Chlorite	122: 3, 5
Felsite	101: 10, 12	Chrysoberyl	123F: 3
Filite	110: 1	Cinnabar	123B: 2
Gabbro	103: 4-6	Cobaltite	123B: 2
Gneiss	101: 9	Corundum	123F: 3
Granite	101: 9-12	Cuprite	123F: 3
Granodiorite	102: 3, 4	Danburite	124: 1
Lava	103: 3, 4	Diaspore	123F: 3
Obsidian	101: 5, 10, 12	Dolomite	123A: 1, 2
Pegmatite	101: 8, 9	Dumortierite	124: 2
Peridotite	103: 5, 6	Enargite	123B: 3
		Feldspar	101: 9; 121: 1
		Franklinite	123F: 6
		Galena	123B: 3

Gibbsite	123F: 4	Psilomelane	123F: 5
Goethite	123F: 4	Pyrargyrite	123B: 6
Gypsum	123B: 3, 4	Pyrite	123B: 6
Hematite	123F: 4	Pyrolusite	123F: 6
Hornblende	101: 10, 11; 102: 3-5; 103: 4	Pyroxene	121: 4; 122: 4
Ilmenite	123F: 4	Pyrrhotite	123B: 6
Jamesonite	123B: 4	Quartz	101: 9; 121: 4, 5; 123: 1
Jarosite	123B: 4	Realgar	123B: 6
Kaolinite	121: 1	Rhodochrosite	123A: 3; 132: 1
Limonite	123F: 1, 2, 5	Rutile	123F: 6
Magnesite	123A: 2	Serpentine	103: 5, 6; 122: 5
Magnetite	123F: 5	Siderite	123A: 3
Malachite	123A: 2	Smithsonite	123A: 3
Marcasite	123B: 5	Sphalerite	123B: 7
Molybdenite	123B: 5	Stibnite	123B: 7
Montmorillonite	121: 1, 2	Strontianite	123A: 3
Muscovite	121: 2	Sublimate	123B: 7
Nephelene	124: 2	Sulphur	123B: 7
Niccolite	123B: 5	Talc	122: 3
Olivine	122: 3, 4	Thenardite	123B: 8
Orthoclase	121: 2	Witherite	123A: 4
Plagioclase	121: 2, 3	Zincite	123F: 7
Proustite	123B: 5		

#### 4

#### DATA PLOTS

This section contains a summary of the information added to the ERSIS in 1971. The data have been categorized by subject and organized in the following manner: soils, vegetation, and rocks and minerals. Within each of these sections, the data have been grouped by either their general or specific subject-descriptor code. For instance, Clay is grouped under its specific subject code as section BFGC. However, Barium Carbonate (Witherite), subject code 123A10, is grouped under its more general code as section 123A (Carbonate Minerals). The purpose of the more general grouping is conservation of space, especially since many subject categories contain only one plot.

Curves of the same rock or mineral type, but of differing particle size, have been plotted on one grid as a composite plot; all other curves appear as single plots. Included with each plot, composite or single, is a title listing of the material measured plus the curve and document numbers: these completely identify the curve source.

The following definitions have been included to facilitate use of the data:

- (1) Bidirectional Reflectance. The source is collimated about a small solid angle, and the receiver aperture is small; the angles of incidence and observation are approximately discrete.

- (2) Directional Reflectance. Either the source or the receiver is collimated about a small solid angle, and the other is spread over the hemisphere. For instance, a parabolic reflectometer, which illuminates the sample equally over the hemisphere and which receives reflected energy at specific angles, yields directional reflectance data. Likewise, a total integrating sphere, which illuminates the sample at one angle and collects reflected energy over the whole hemisphere, gives directional reflectance data. Most of the data in ERSIS are examples of directional reflectance, because most were measured with an integrating sphere attachment, such as the Beckman data.
- (3) Degree of Polarization.\* The beam is divided into a pair of completely and orthogonally polarized components that have the maximum difference in intensity. The dominant component is called  $I_{\max}$ , and the inferior component is called  $I_{\min}$ . Degree of polarization is then given by

$$\frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

which is a dimensionless number between 0 and 1. The percentage of polarization is 100 times the degree of polarization. Note: Some investigators (such as Coulson) define degree of polarization as

$$\frac{I_{\perp} - I_{\parallel}}{I_{\perp} + I_{\parallel}}$$

which permits negative values, depending on the relative sizes of  $I_{\perp}$  and  $I_{\parallel}$ .

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\* Definition from W. A. Shurcliff, Polarized Light, Harvard University Press, Cambridge, Mass., 1965.

## Appendix I

### SUMMARY OF EXPERIMENTS YIELDING OPTICAL DATA

Each of the data curves published in this report has an identification number consisting of nine characters. The first of these is an alphabetic symbol, and the remaining eight are numeric. The alphabetic symbol is used to designate the original source of the data and to differentiate between measurements coordinated under various sponsored efforts.

The symbol B, used as a prefix to the identification number, is used to identify data taken from reports kept on file at The University of Michigan, Willow Run Laboratories. In these cases, the first five digits identify the document from which the data were taken; the last three digits indicate the curve within the document.

The documents from which the optical data have been extracted are briefly summarized on the following pages. These summaries are included to facilitate use of the data presented in Section 4. Information on the experimental platform, instrumentation, reflectance standards (for relative data), and other related matters has been included, and additional references describing some of the instrumentation in greater detail are cited. Bibliographical information on each of the documents is stated; the user is referred to the original source if more detailed information is required.

B09000. Hunt, Salisbury: "Visible and Near-Infrared Spectra of Minerals and Rocks: I. Silicate Minerals," *Mod. Geol.*, Vol. I, 1970, pp. 283-300.

Platform: laboratory

Instrument: Cary Model 14

Quantity measured: relative bidirectional reflectance (%)

Wavelength range: 0.3 to 2.6  $\mu\text{m}$

Reflectance attachment: original design, see comments

Reflectance standard: MgO

Comments: Reflectance was measured for particulate samples of various particle diameter ranges. Some grinder steel contamination was present, affecting primarily the high-reflectance-sample spectra; see author's comment for further discussion.

Additional reference: see B09004 and Ref. [1], Appendix I.2.9.

B09001. Daniels: Additional Infrared Spectral Emittance Measurements of Rocks from the Mono Craters, California, Interagency Report NASA-90, Department of the Interior Geological Survey, Washington, D. C., October 1967.

Platform: laboratory

Instrument: Block Engineering Inc. Model I-4T Interferometer Spectrometer

Quantity measured: spectral emittance (%)

Wavelength range: 7.7 to 14.3  $\mu\text{m}$

Emission attachment: see comments

Emission standard: blackbody cavity

Comments: Flat side of sample is placed on hot plate and heated to 345°K. Hot plate and sample are enclosed in an aluminum box measuring 7 × 7 × 7 in. with 1/2-in. walls blackened on the inner surface. The upper surface of sample radiates into the spectrometer through a hole in the top of the box. The data obtained are relative to the blackbody cavity but are corrected for temperature. Corrections are not made for emission from the walls of the aluminum box.

Additional reference: [8]

B09002. Daniels: Infrared Spectral Emittance of Rocks from the Pisgah Crater and Mono Craters Areas, California, Earth Resources Survey Program Technical Letter NASA Supplement-13A, U. S. Geological Survey, Washington, D. C., July 1967.

Platform: laboratory

Instrument: Block Engineering Inc. Model I-4T Interferometer Spectrometer

Quantity measured: spectral emittance (%)

Wavelength range: 7.4 to 14.8  $\mu\text{m}$

Emission attachment: see comments

Emission standard: blackbody cavity

Comments: see B09001

Additional Reference: [8]

B09004. Hunt, Ross: "A Bidirectional Reflectance Accessory for Spectroscopic Measurements," Appl. Opt., Vol. 6, No. 10, October 1967, pp. 1687-1690.

Platform: laboratory

Instrument: Cary Model 14

Quantity measured: relative bidirectional reflectance (%)

Wavelength range: 0.2 to 2.6  $\mu\text{m}$

Reflectance attachment: see comments

Reflectance standard: MgO

Comments: The bidirectional reflectance attachment requires a fixed phase angle, though sample normal can be varied.

B09005. Hunt, Salisbury: "Visible and Near-Infrared Spectra of Minerals and Rocks: III. Oxides and Hydroxides," Mod. Geol., Vol. II, 1971, pp. 195-205.

Platform: laboratory

Instrument: Cary Model 14

Quantity measured: relative bidirectional reflectance (%)

Wavelength range: 0.3 to 2.5  $\mu\text{m}$

Reflectance attachment: see B09000

Reflectance standard: MgO

Comments and additional reference: see B09000

B09006. Gomes de Oliveira: "Reflectancia Infrarroja de Algunas Rocas Mexicanas Entre 2.5 y 22 Micras," Bol. Soc. Geol. Mexicana, t. XXX, n. 1, 1967, pp. 63-74.

Platform: laboratory

Instrument: Cary Model 90

Quantity measured: directional reflectance (%)

Wavelength range: 2.5 to 22.0  $\mu\text{m}$

Reflectance attachment: integrating sphere

Reflectance standard: attenuated beam

Comments: document written in Spanish

B09008. Hunt, Salisbury: "Visible and Near-Infrared Spectra of Minerals and Rocks: II. Carbonates," Mod. Geol., Vol. II, 1971, pp. 23-30.

Platform: laboratory

Instrument: Cary Model 14

Quantity measured: relative bidirectional reflectance (%)

Wavelength range: 0.3 to 2.6  $\mu\text{m}$

Reflectance attachment: see B09000

Reflectance standard: MgO

Comments and additional reference: see B09000

B09009. Hunt, Salisbury: "Visible and Near-Infrared Spectra of Minerals and Rocks: IV. Sulphides and Sulphates," accepted by Mod. Geol. for 1971.

Platform: laboratory

Instrument: Cary Model 14

Quantity measured: relative bidirectional reflectance (%)

Wavelength range: 0.3 to 2.6  $\mu\text{m}$

Reflectance attachment: see B09000

Reflectance standard: MgO

Comments and additional reference: see B09000

B09010. Coulson, Bouricius, Gray: Effect of Surface Properties on Planet-Reflected Sunlight, Report NAS 5-3925, General Electric Missile and Space Division, November 1964.

Platform: laboratory

Instrument: original design

Quantity measured: degree of polarization (%) and relative bidirectional reflectance (%)

Wavelength range: 0.492, 0.520, 0.643, 0.796

Comments: Degree of polarization is defined such that it can be negative. Relative transmission of filters used is given in document.

B09011. Condit: "The Spectral Reflectance of American Soils," Photogrammetric Eng., September 1970, pp. 955-966.

Platform: laboratory

Instrument 1: Cary Model 14

Quantity measured: directional reflectance (%)

Wavelength range: 0.32 to 0.80  $\mu\text{m}$

Reflectance attachment: nonhemispherical diffuse reflectance attachment

Reflectance standard: MgO

Comments: see Instrument 2

Instrument 2: Beckman DU Spectrophotometer

Quantity measured: directional reflectance

Wavelength range: 0.8 to 1.0  $\mu\text{m}$

Reflectance attachment: nonhemispherical diffuse reflectance attachment

Reflectance standard: MgO

Comments: The data obtained are relative to MgO but have been converted to absolute. The soils samples were thoroughly dried before preparation for measurement. The samples were moderately packed by sliding a flat piece of plexiglass across the top of the sample holder.

B09012. Ross, Adler, Hunt: "A Statistical Analysis of the Reflectance of Igneous Rocks from 0.2 to 2.65 Microns," Icarus, Vol. 11, 1969, pp. 46-54.

Platform: laboratory

Instrument: Cary Model 14

Quantity measured: relative bidirectional reflectance (%)

Wavelength range: 0.2 to 2.6  $\mu\text{m}$

Reflectance attachment: see B09000

Reflectance standard: MgO

Comments and additional reference: see B09000

B09013. Gausman, Allen, Cardenas, et al.: "Effects of Leaf Nodal Position on Absorption and Scattering Coefficients and Infinite Reflectance of Cotton Leaves" and "Age Effects of Growth Chamber-, Greenhouse-, and Field-Grown Cotton Leaves on Light Reflectance, Transmittance, and Absorptance and on Water Content and Thickness," 2 papers from



Spectral Survey of Irrigated Region Crops and Soils, 1970 Annual Report, U. S. Department of Agriculture, Weslaco, Texas.

Platform: laboratory

Instrument: Beckman Model DK-2

Quantity measured: directional reflectance (%)

Wavelength range: 0.5 to 2.5  $\mu\text{m}$

Reflectance attachment: integrating sphere

Reflectance standard: MgO

Comments: The data have obtained relative to MgO, but have been converted to absolute.

Additional reference: [1] Appendix I.2.2.

B09014. Gausman, Allen, Cardenas, Richardson: "Relation of Light Reflectance to Histological and Physical Evaluations of Cotton Leaf Maturity," Appl. Opt., Vol. 9, No. 3, March 1970, pp. 545-552.

Platform: laboratory

Instrument: Beckman Model DK-2

Quantity measured: directional reflectance and transmittance

Wavelength attachment: integrating sphere

Reflectance standard: MgO

Comments: These data have been obtained relative to MgO, but have been converted to absolute.

Additional reference: [1] Appendix I.2.2.

## Appendix II

### LIST OF RELATED REPORTS

The following reports describe remote sensing work performed by the Infrared and Optics Laboratory, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan.

OPTICAL TRANSFER TECHNIQUES FOR ORBITAL SCANNERS, J. Braithwaite, E. Work, Report No. 31650-21-T, March 1971.

DETECTOR UTILIZATION IN LINE SCANNERS, L. Larsen, Report No. 31650-29-T, August 1971.

A PROTOTYPE HYBRID MULTISPECTRAL PROCESSOR (SPARC/H) WITH HIGH THROUGHPUT CAPABILITY, F. Kriegler, R. Marshall, Report No. 31650-23-T, March 1971.

DATA DISPLAY REQUIREMENTS FOR A MULTISPECTRAL SCANNER PROCESSOR WITH HIGH THROUGHPUT CAPABILITY, R. E. Marshall, F. J. Kriegler, Report No. 31650-28-L, July 1971.

CALIBRATION OF MULTISPECTRAL SCANNERS, J. Braithwaite, Report No. 31650-27-L, September 1970.

STUDIES OF SPECTRAL DISCRIMINATION, W. A. Malila, et al., Report No. 31650-22-T, May 1971.

- INVESTIGATIONS OF MULTISPECTRAL SENSING OF CROPS, R. Nalepka, et al., Report No. 31650-30-T, May 1971.
- INVESTIGATION OF SHALLOW WATER FEATURES, F. Polcyn, et al., Report No. 31650-31-T, August 1971.
- THE NASA EARTH RESOURCES SPECTRAL INFORMATION SYSTEM: A DATA COMPILATION, V. Leeman, et al., Report No. 31650-24-T, May 1971.
- NASA/MSC EARTH RESOURCES SPECTRAL INFORMATION SYSTEM PROCEDURES MANUAL, V. Leeman, et al., Report No. 31650-32-T, 1971.
- DATA GAPS IN THE NASA EARTH RESOURCES SPECTRAL INFORMATION SYSTEM, R. Vincent, Report No. 31650-25-T, March 1971.
- REMOTE SENSING DATA ANALYSIS PROJECTS ASSOCIATED WITH THE NASA EARTH RESOURCES SPECTRAL INFORMATION SYSTEM, R. Vincent, et al., Report No. 31650-26-T, April 1971.
- INVESTIGATIONS RELATED TO MULTISPECTRAL IMAGING SYSTEMS FOR REMOTE SENSING, J. Erickson, Report No. 31650-17-P, September 1971.
- INVESTIGATIONS RELATED TO MULTISPECTRAL IMAGING SYSTEMS (Final Report), J. Erickson, Report No. 31650-18-F [in publication].
- NASA/MSC EARTH RESOURCES SPECTRAL INFORMATION SYSTEM PROCEDURES MANUAL, SUPPLEMENT, V. Leeman, Report No. 31650-72-T, September 1971.
- ESTIMATING PROPORTIONS OF OBJECTS FROM MULTISPECTRAL DATA, R. Nalepka, et al., Report No. 31650-73-T [in publication].
- INFORMATION EXTRACTION TECHNIQUES, W. Malila, et al., Report No. 31650-74-T [in publication].
- DISCRIMINATION TECHNIQUES EMPLOYING BOTH REFLECTIVE AND THERMAL MULTISPECTRAL SIGNALS, W. Malila, Report No. 31650-75-T [in publication].
- ROCK-TYPE DISSEMINATION FROM RATIO IMAGES OF THE PISGAH CRATER, CALIFORNIA TEST SITE, R. Vincent, et al., Report No. 31650-77-T [in publication].
- INVESTIGATION OF THE THEORETICAL METHODS FOR THE OPTICAL MODELING OF AGRICULTURAL FIELDS, R. Vincent, Report No. 31650-78-T, [in publication].

# REFERENCES

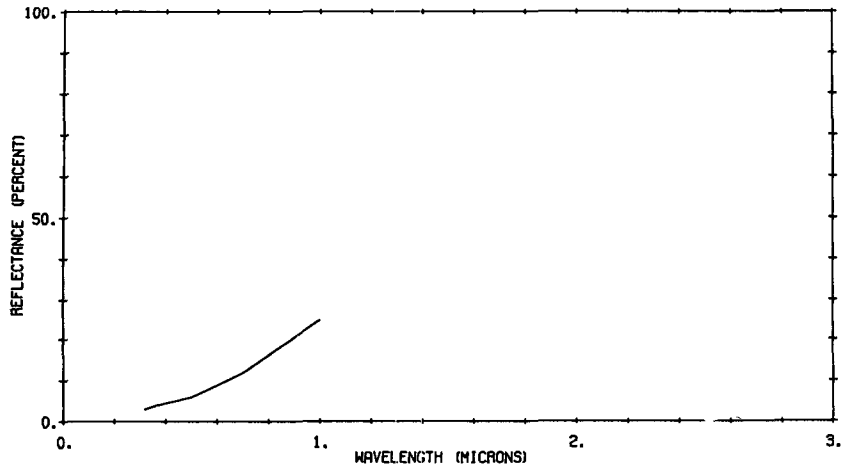
1. V. Leeman, et al., NASA Earth Resources Spectral Information System: A Data Compilation, Report No. 31650-24-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, May 1971.
2. R. Vincent, Data Gaps in the NASA Earth Resources Spectral Information System, Report No. 31650-25-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, March 1971.
3. R. Vincent, et al., Remote Sensing Data Analysis Projects Associated with the NASA Earth Resources Spectral Information System, Report No. 31650-26-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, April 1971.
4. V. Leeman, et al., NASA/MSC Earth Resources Spectral Information System Procedures Manual, Report No. 31650-32-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, 1971.
5. V. Leeman, NASA/MSC Earth Resources Spectral Information System Procedures Manual, Supplement, Report No. 31650-72-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, September 1971.
6. R. Vincent, et al., Rock-Type Dissemination from Ratio Images of the Pisgah Crater, California Test Site, Report No. 31650-77-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan [in publication].
7. R. Vincent, Investigation of the Theoretical Methods for the Optical Modeling of Agricultural Fields, Report No. 31650-78-T, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan [in publication].
8. D. L. Daniels, Infrared Spectral Emittances from the Pisgah Crater and Mono Craters Areas, California, Technical Letter NASA-13, U. S. Geological Survey, 1966.

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SOIL

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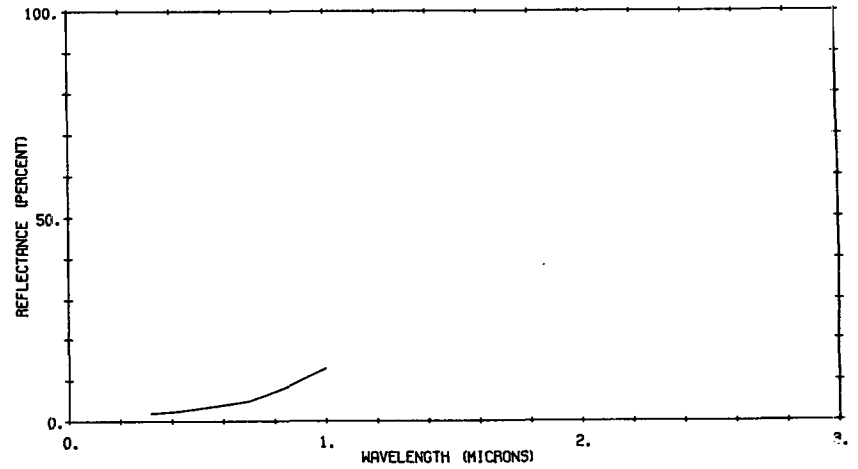
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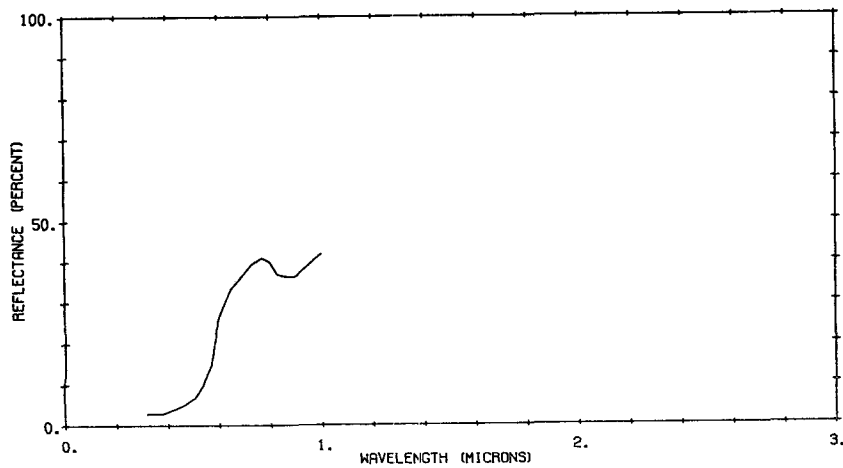
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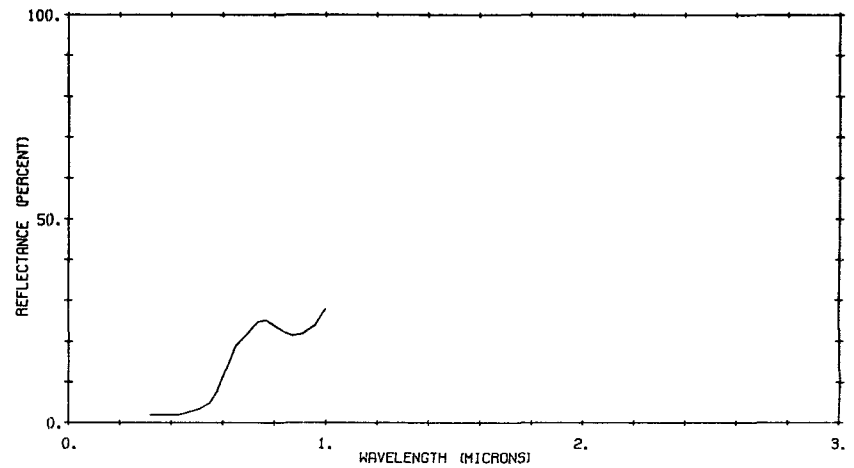
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B09011 007

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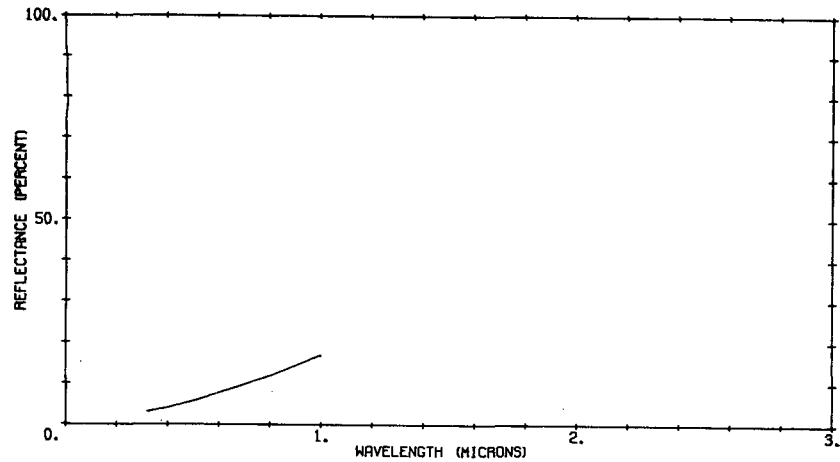
B09011 008

LATERITE-TYPE SOIL (5 MI. N. OF CHARLOTTESVILLE, VA.), WET.



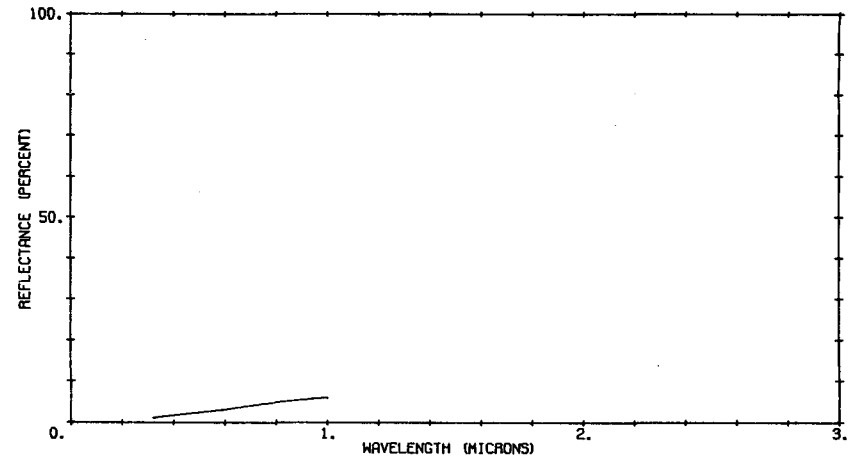
B09011 009

CHERNOZEM-TYPE SOIL (4 MI. N. OF NEODESHA, KANSAS), DRY.



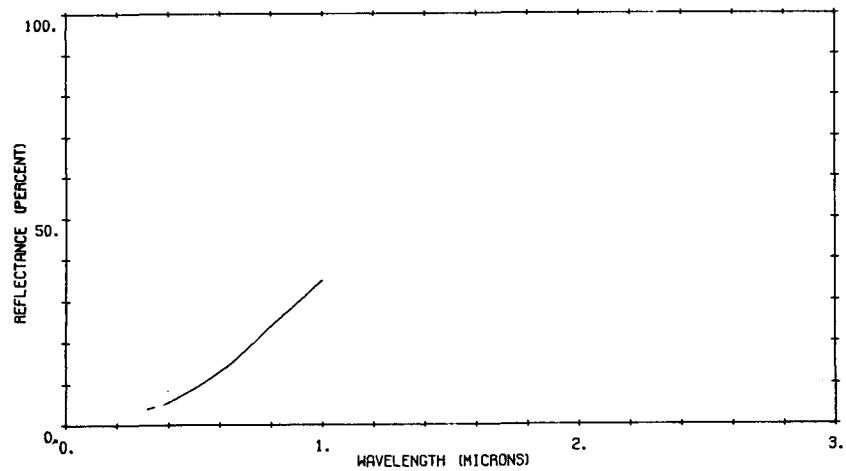
B09011 010

CHERNOZEM-TYPE SOIL (4 MI. N. OF NEODESHA, KANSAS), WET.



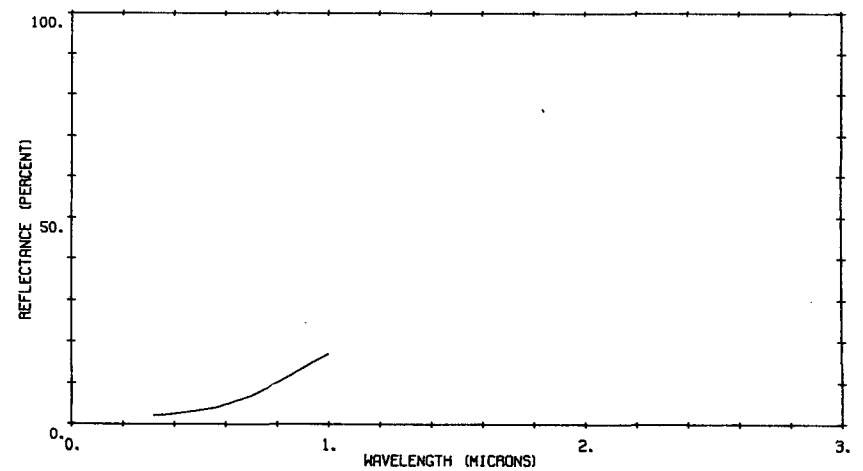
B09011 011

CHERNOZEM-TYPE SOIL (4 MI. S.E. OF AVENT, OKLAHOMA), DRY.



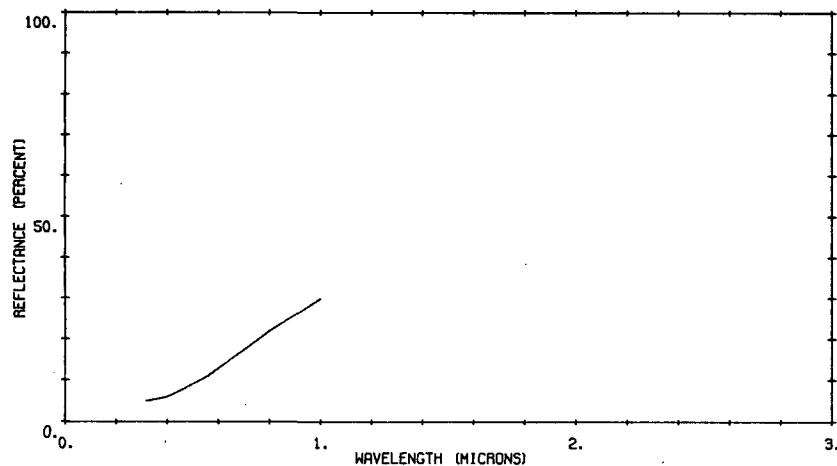
B09011 012

CHERNOZEM-TYPE SOIL (4 MI. S.E. OF AVENT, OKLAHOMA), WET.



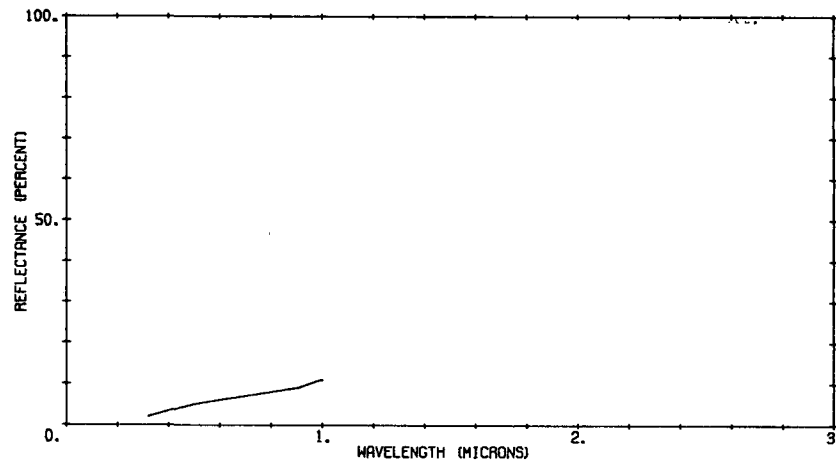
B09011 015

CHERNOZEM-TYPE SOIL (1 MI. E. OF LINDSBORG, KANSAS), DRY.



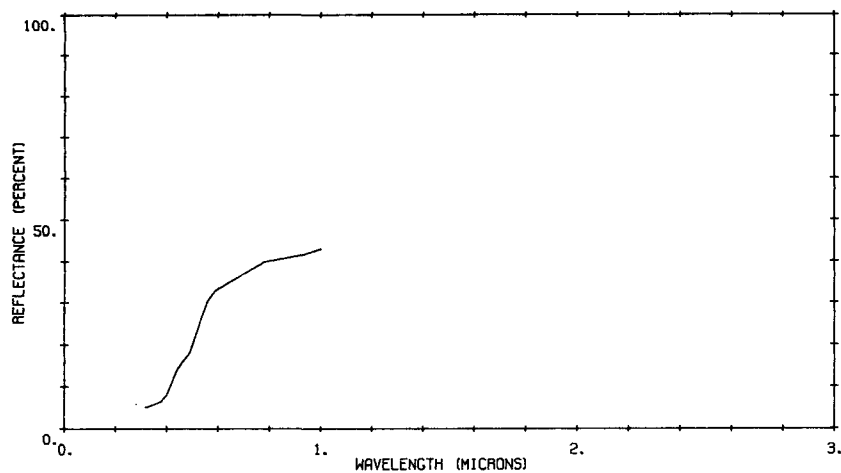
B09011 016

CHERNOZEM-TYPE SOIL (1 MI. E. OF LINDSBORG, KANSAS), WET.



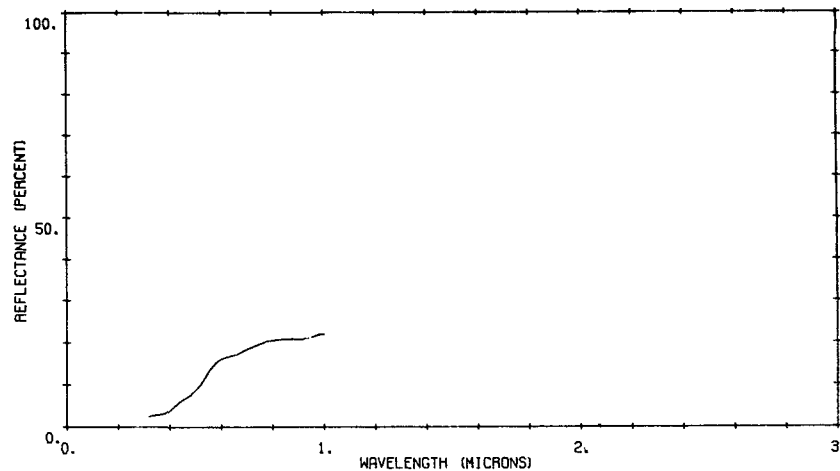
B09011 023

PEDOCAL-TYPE SOIL (1 MI. S. OF SAGAMORE HILLS, OHIO), DRY.



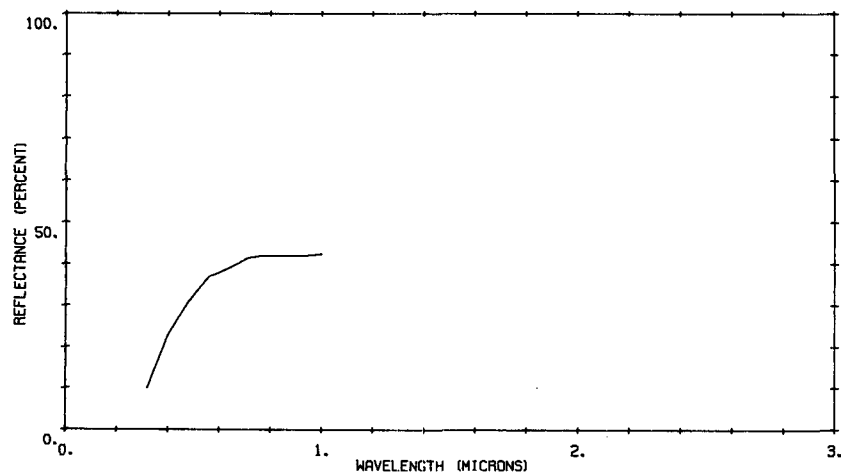
B09011 024

PEDOCAL-TYPE SOIL (1 MI. S. OF SAGAMORE HILLS, OHIO), WET.



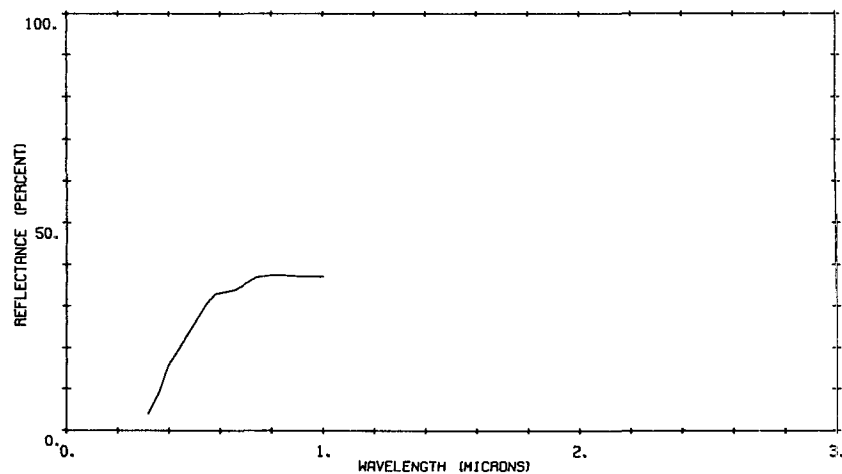
B09011 029

PEDOCAL-TYPE SOIL (10 MI. S. OF LYMAN, NEBRASKA), DRY.



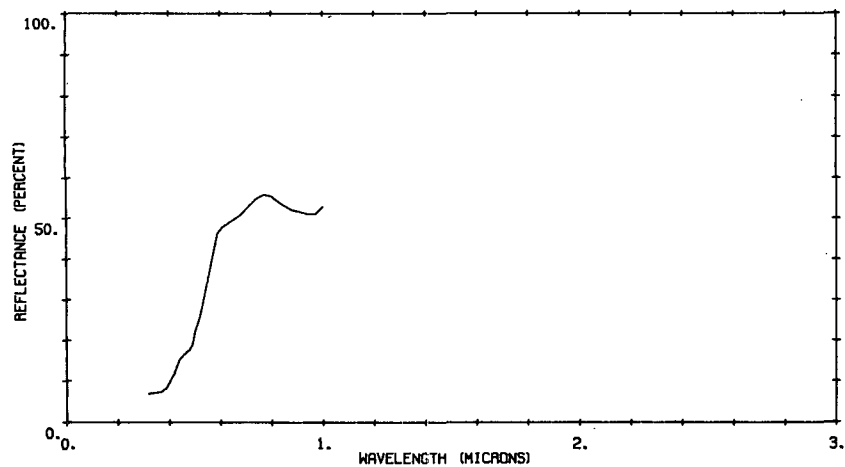
B09011 030

PEDOCAL-TYPE SOIL (10 MI. S. OF LYMAN, NEBRASKA), WET.



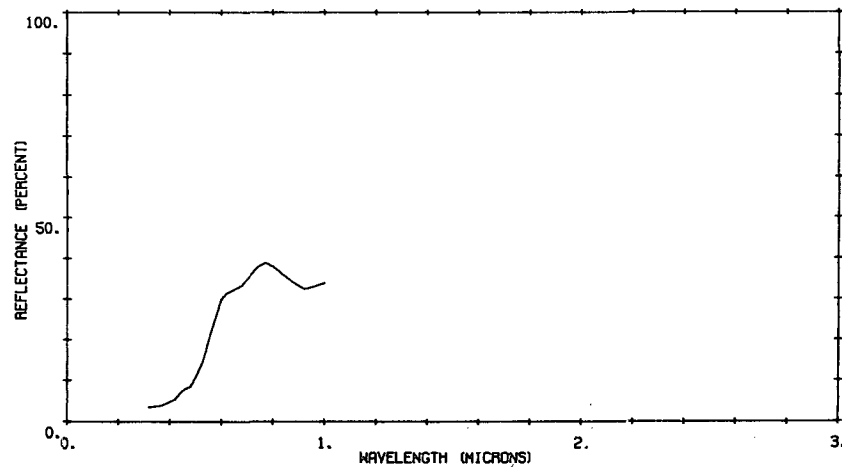
52 B09011 035

PEDALFER-TYPE (12 MI. N. OF DALTON, GEORGIA), DRY.



B09011 036

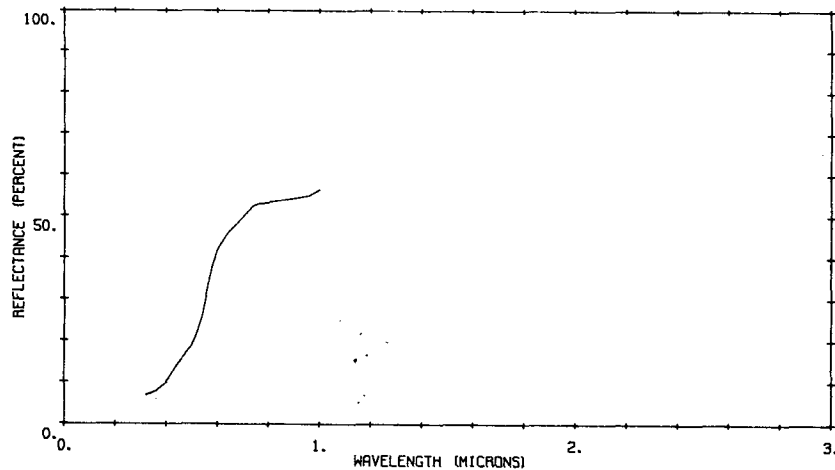
PEDALFER-TYPE (12 MI. N. OF DALTON, GEORGIA), WET.





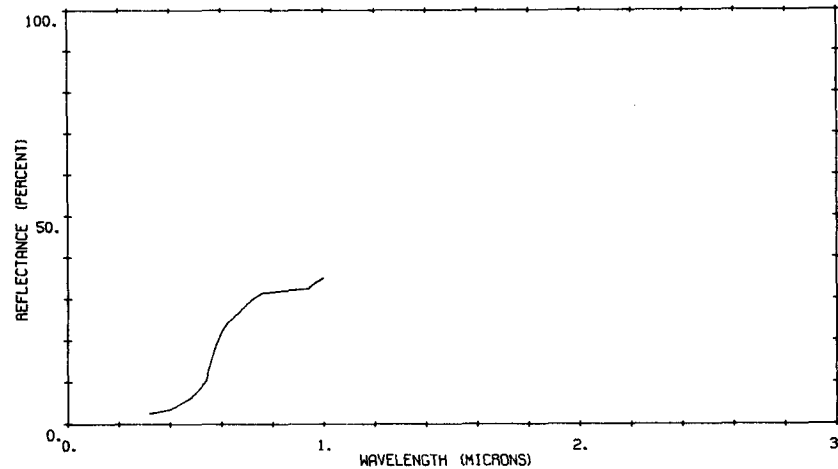
B09011 039

PEDALFER-TYPE SOIL (3 MI. E. OF MOUNTAIN VIEW, MO.), DRY.



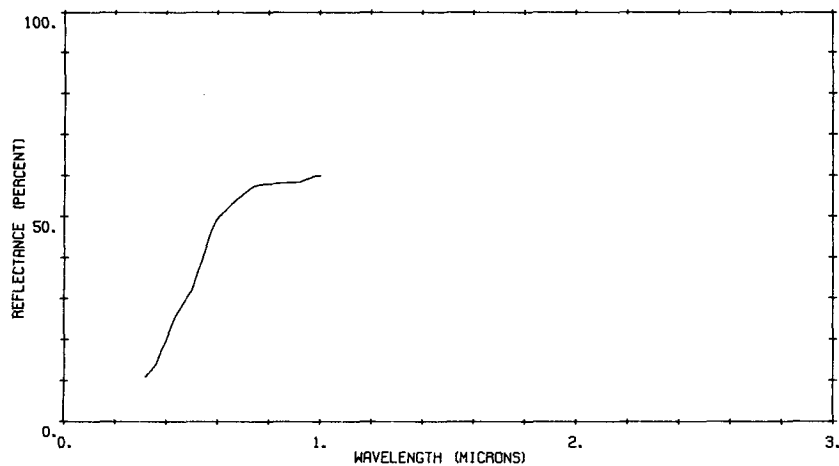
B09011 040

PEDALFER-TYPE SOIL (3 MI. E. OF MOUNTAIN VIEW, MO.), WET.



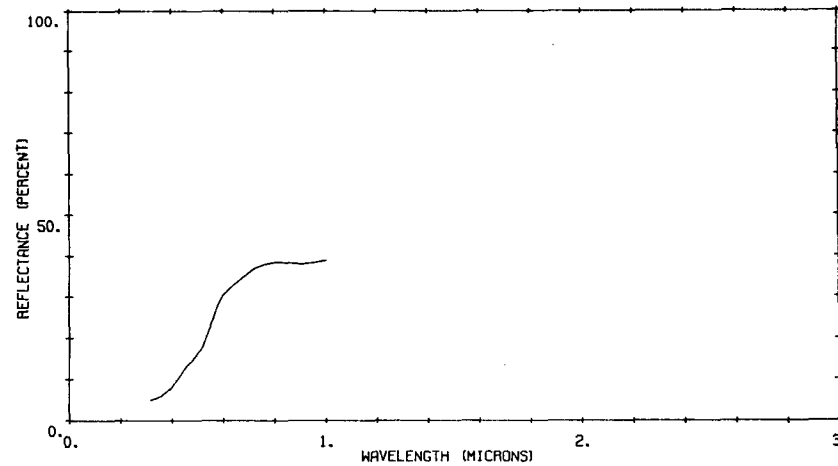
B09011 041

PEDOCAL-TYPE SOIL (3 MI. W. OF PHILLIPSBURG, MISSOURI), DRY.



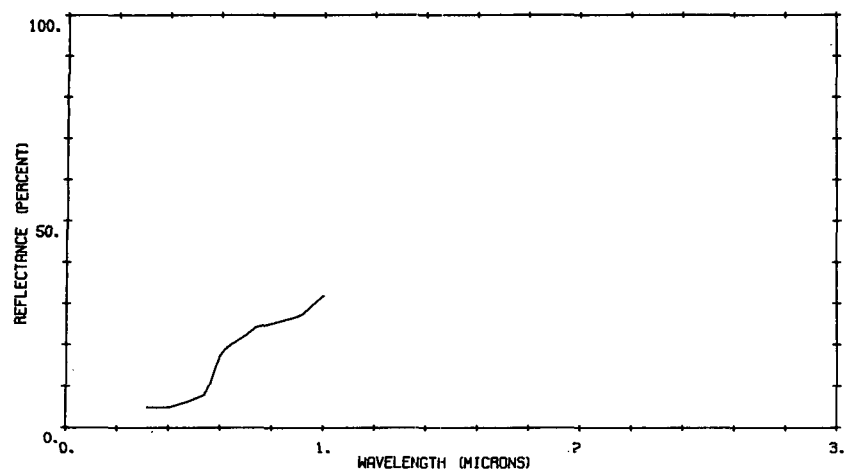
B09011 042

PEDOCAL-TYPE SOIL (3 MI. W. OF PHILLIPSBURG, MISSOURI), WET.



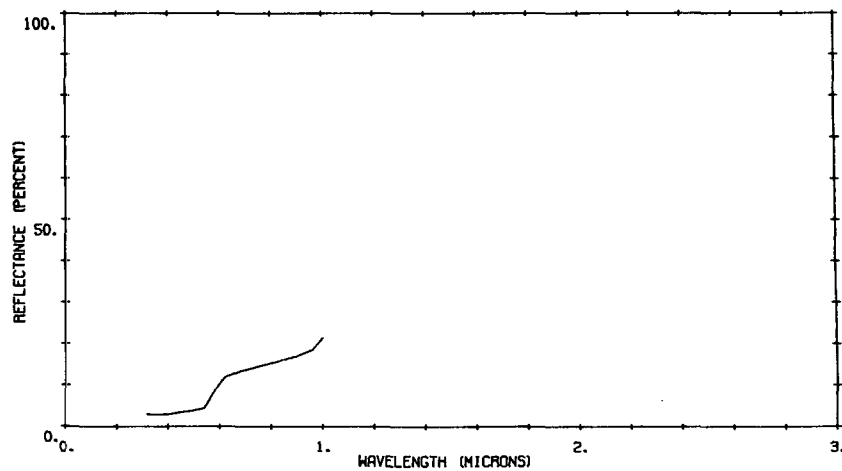
B09011 045

PEDALFER-TYPE SOIL (GARDEN OF THE GODS, COLORADO), DRY



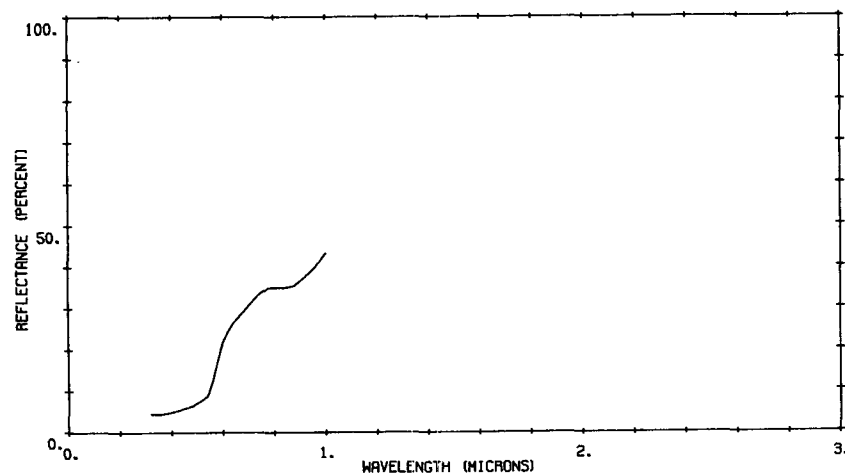
B09011 046

PEDALFER-TYPE SOIL (GARDEN OF THE GODS, COLORADO), WET.



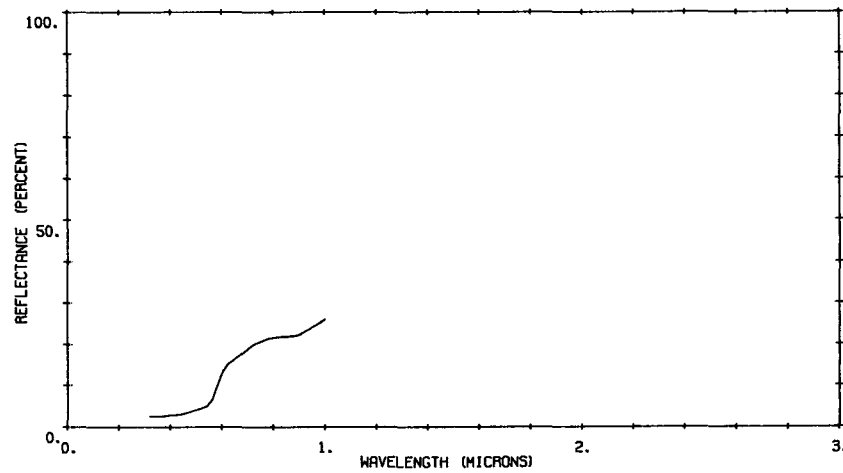
67  
B09011 047

PEDALFER-TYPE SOIL (WOODLAWN, COLORADO), DRY.



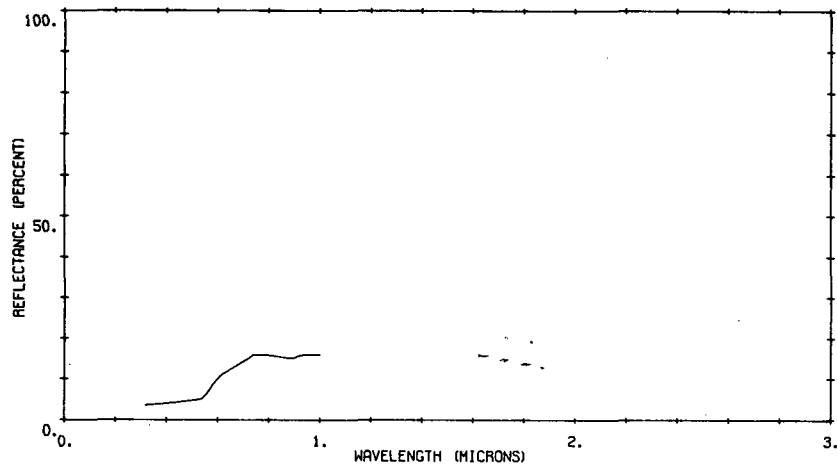
B09011 048

PEDALFER-TYPE SOIL (WOODLAWN, COLORADO), WET.



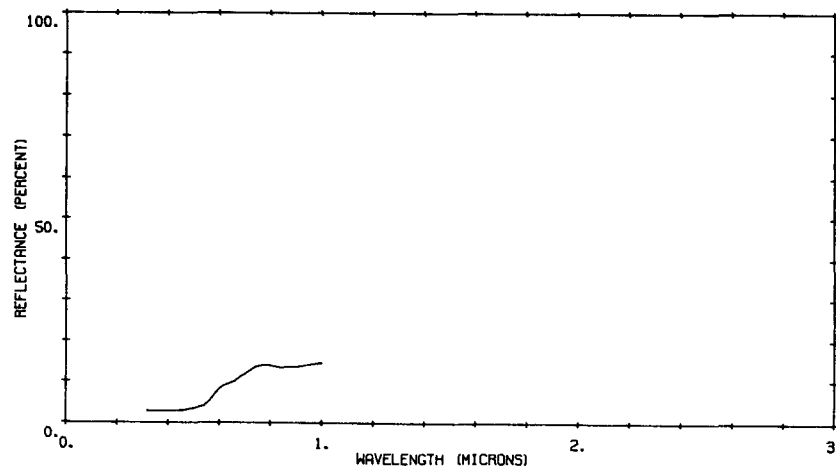
B09011 049

PEDALFER-TYPE SOIL (5 MI. S.E. OF ROWE, NEW MEXICO), DRY.



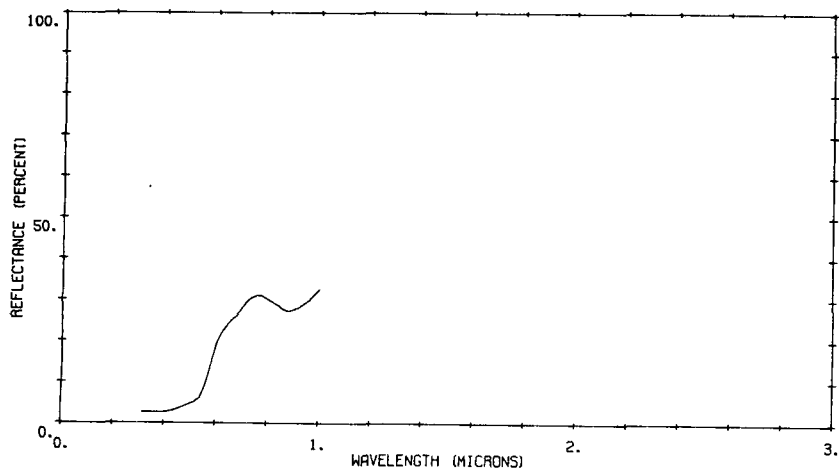
B09011 050

PEDALFER-TYPE SOIL (5 MI. S.E. OF ROWE, NEW MEXICO), WET.



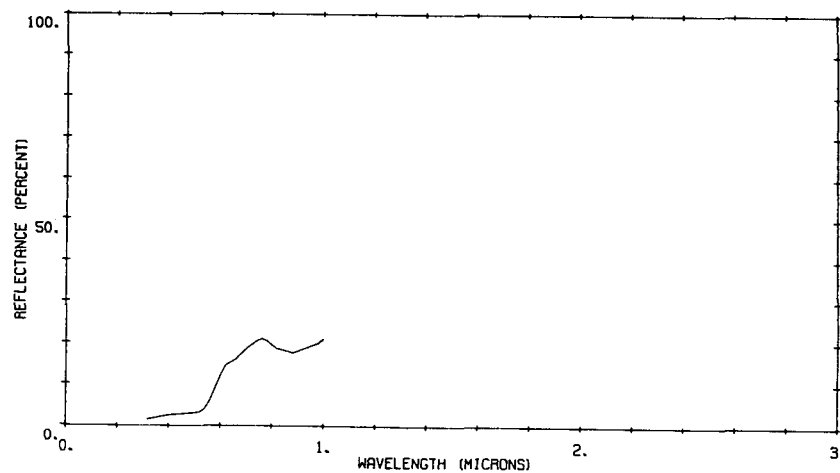
B09011 051

LATERITE-TYPE SOIL (2 MI. N.E. OF LEXINGTON, N. CAR.), DRY.



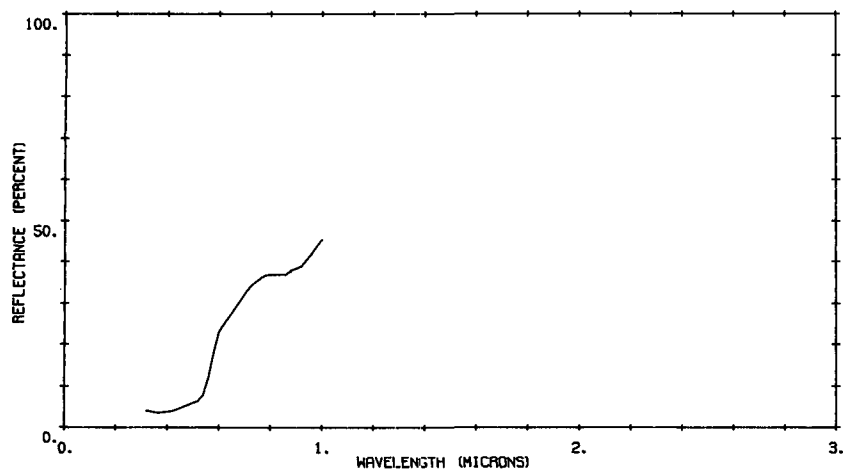
B09011 052

LATERITE-TYPE SOIL (2 MI. N.E. OF LEXINGTON, N. CAR.), WET.



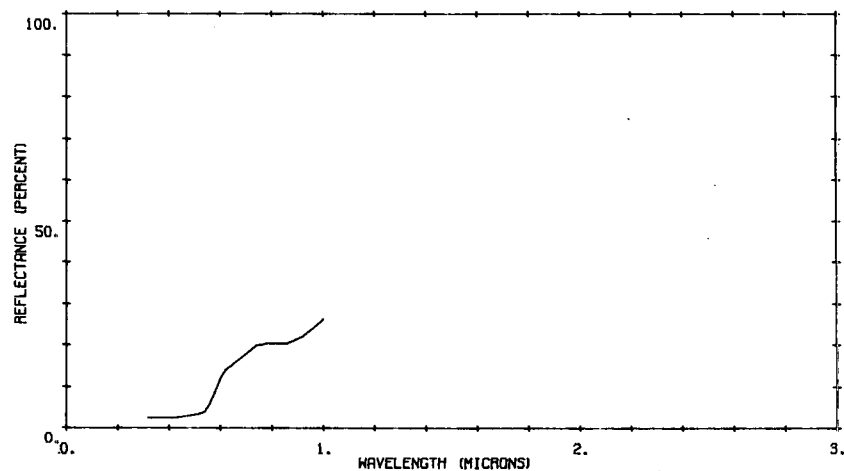
B09011 053

PEDOCAL-TYPE SOIL (12 MI. W. OF ELK CITY, OKLAHOMA), DRY.



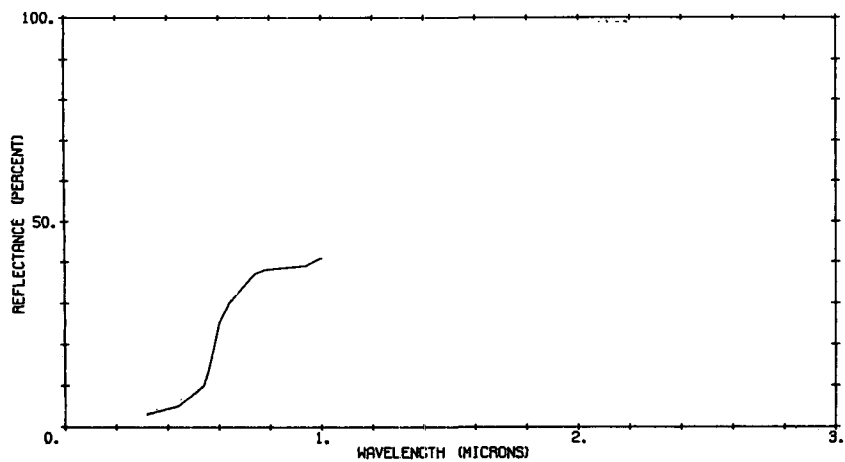
B09011 054

PEDOCAL-TYPE SOIL (12 MI. W. OF ELK CITY, OKLAHOMA), WET.



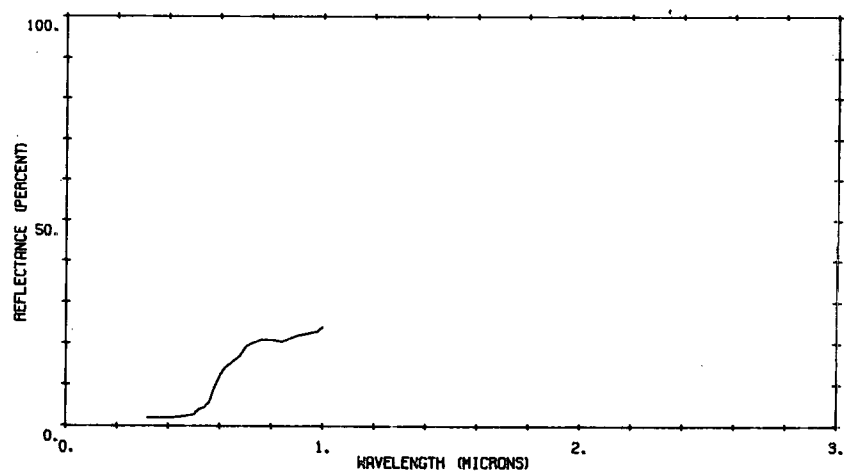
62 B09011 055

PEDALFER-TYPE SOIL (6 MI. N. OF DEL RIO, TEXAS), DRY.



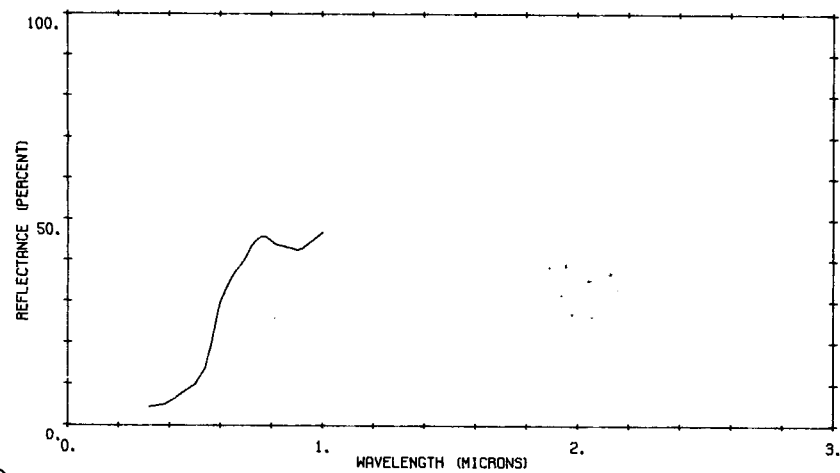
B09011 056

PEDALFER-TYPE SOIL (6 MI. N. OF DEL RIO, TEXAS), WET.



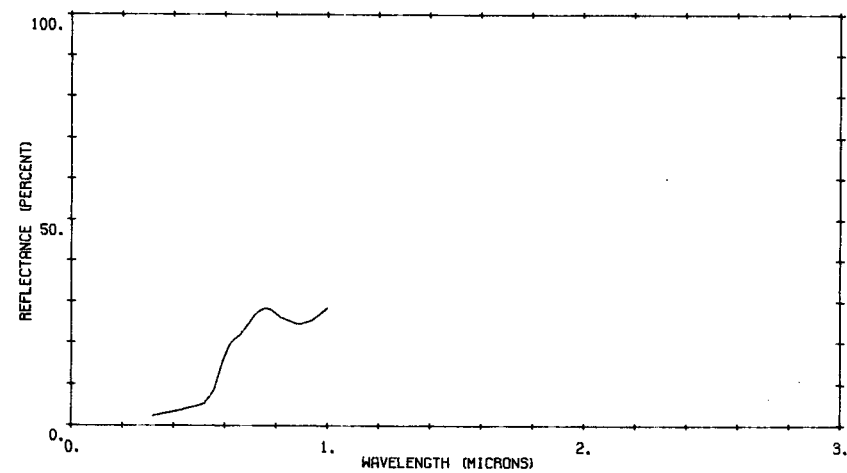
B09011 057

PEDALFER-TYPE SOIL (4 MI. N. OF GRIFFIN, GEORGIA), DRY.



B09011 058

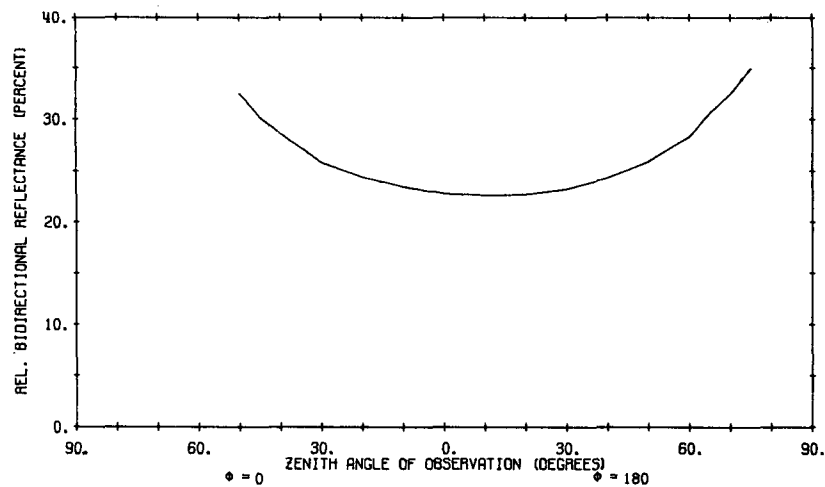
PEDALFER-TYPE SOIL (4 MI. N. OF GRIFFIN, GEORGIA), WET.



BFCA  
SAND

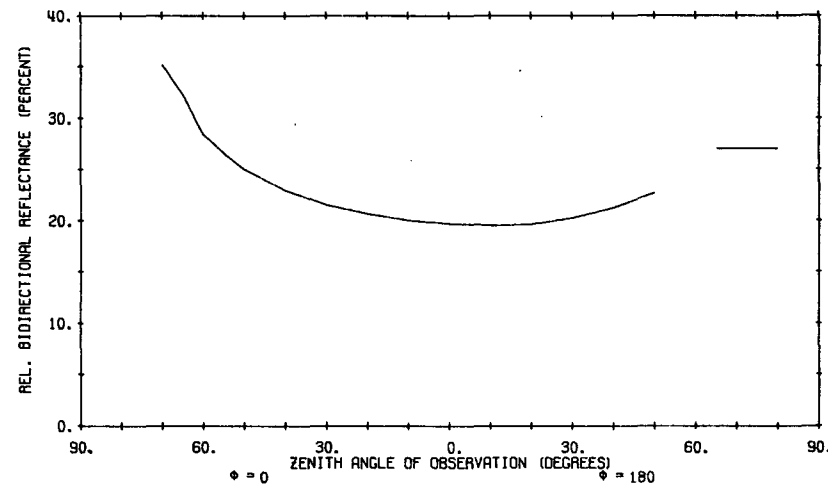
B09010 025

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—78 DEG., WAVELENGTH—.6430 MICRONS.



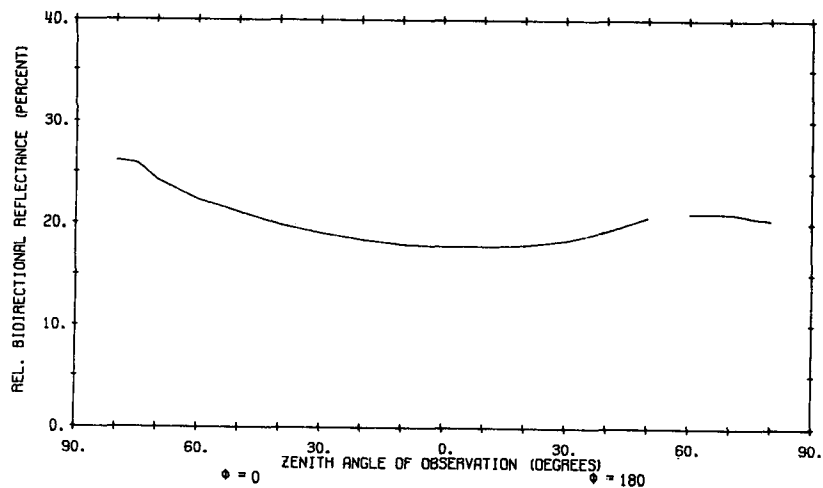
B09010 026

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—66 DEG., WAVELENGTH—.6430 MICRONS.



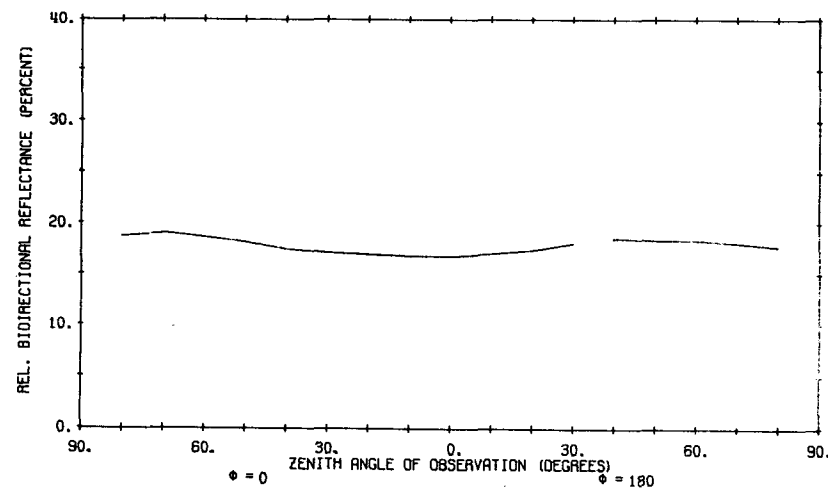
B09010 027

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.6430 MICRONS.



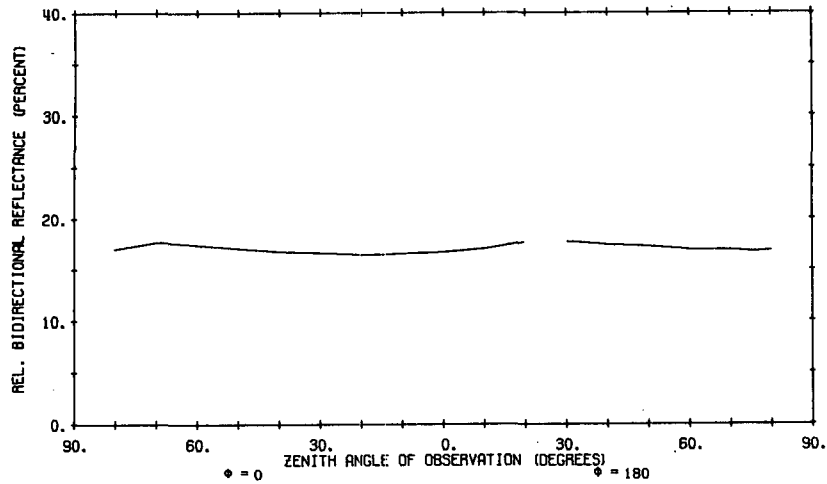
B09010 028

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—37 DEG., WAVELENGTH—.6430 MICRONS.



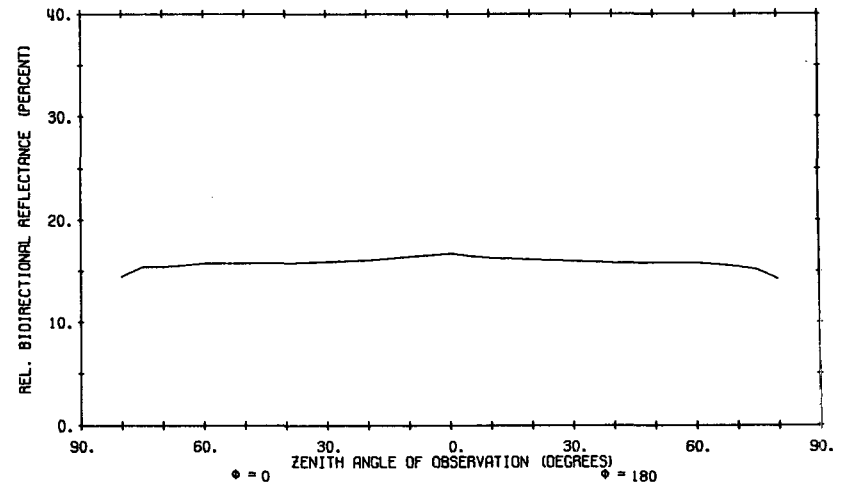
B09010 029

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—23 DEG., WAVELENGTH—.6430 MICRONS.



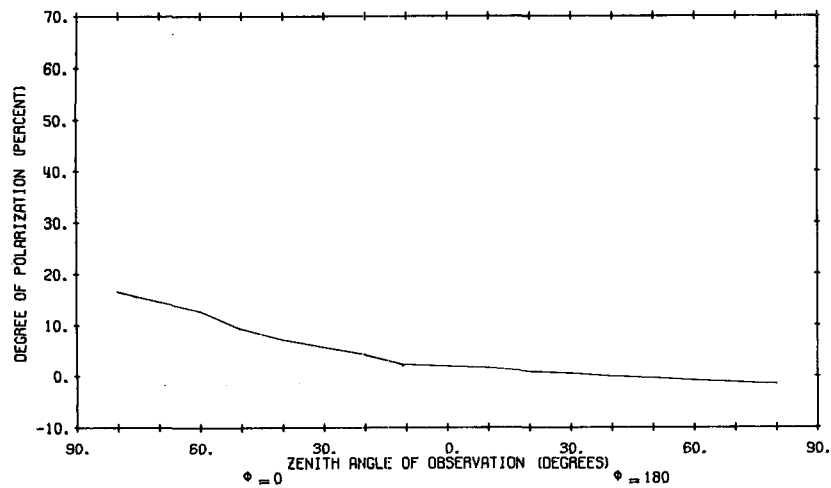
B09010 030

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—0 DEG., WAVELENGTH—.6430 MICRONS.



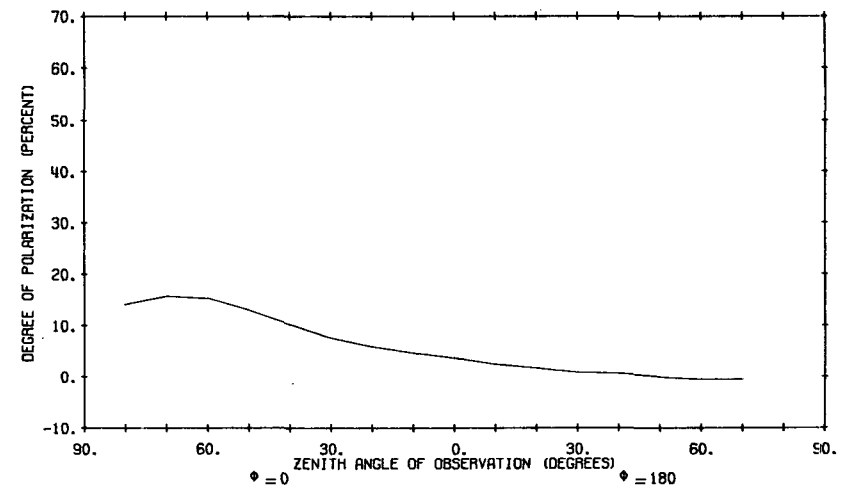
B09010 033

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—67 DEG., WAVELENGTH—.6430 MICRONS.



B09010 034

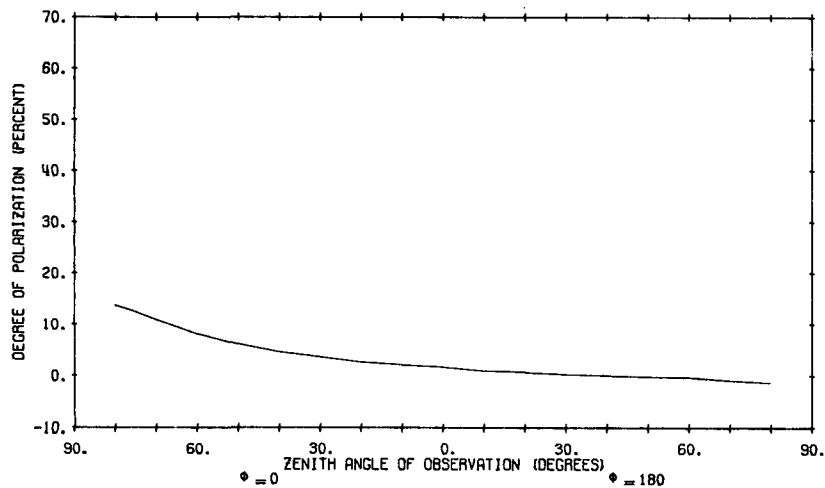
WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—78 DEG., WAVELENGTH—.6430 MICRONS.





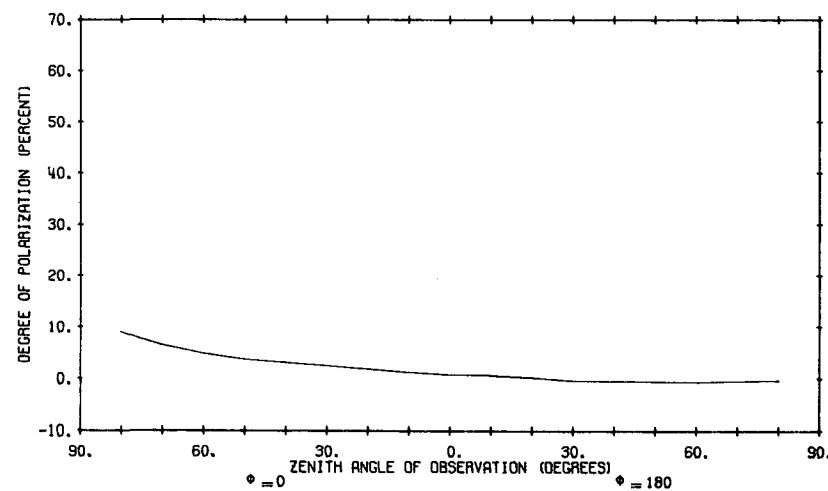
B09010 035

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.6430 MICRONS.



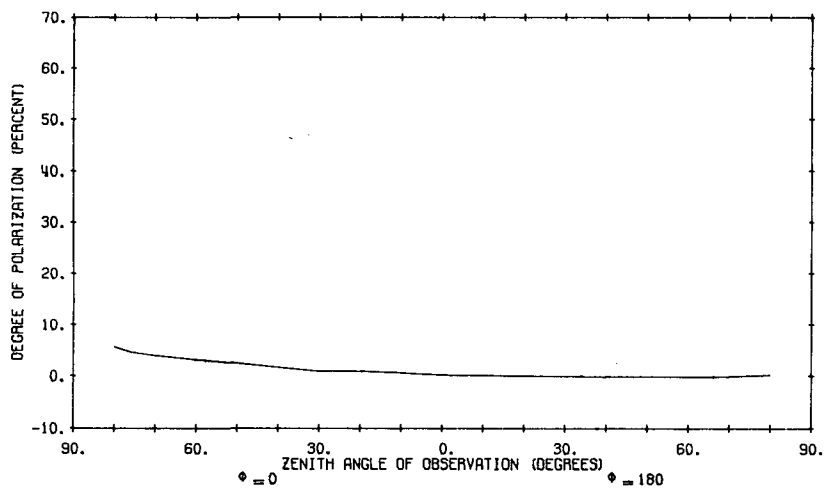
B09010 036

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—37 DEG., WAVELENGTH—.6430 MICRONS.



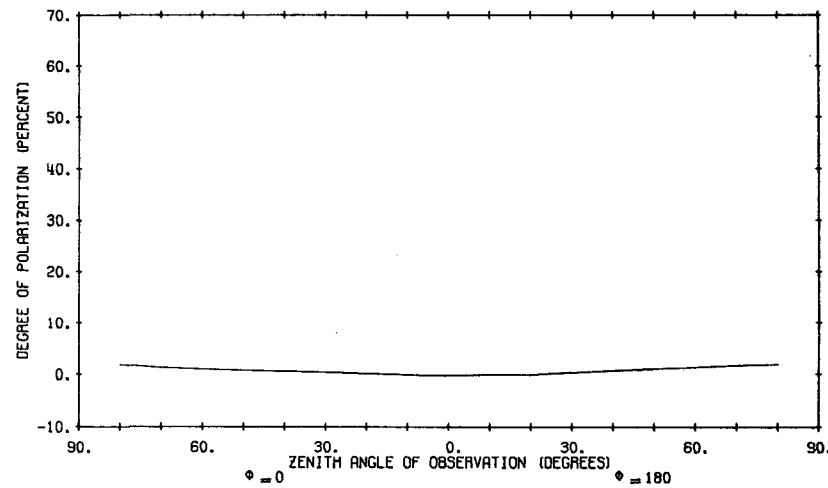
B09010 037

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—23 DEG., WAVELENGTH—.6430 MICRONS.



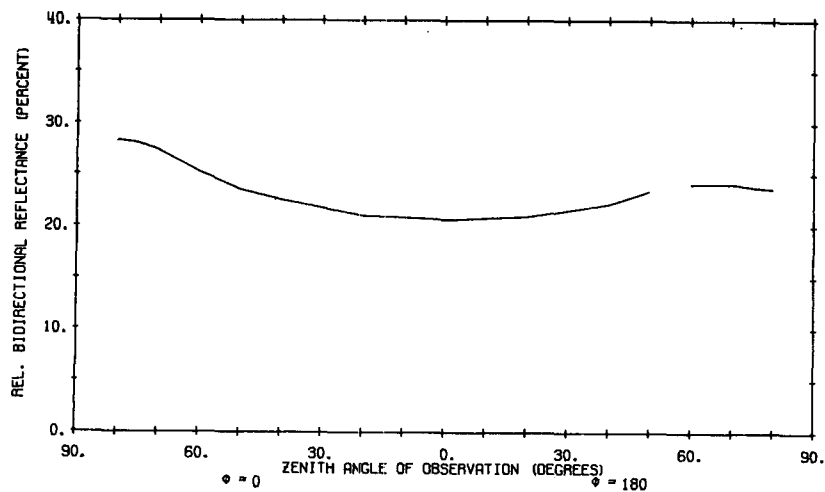
B09010 038

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—0 DEG., WAVELENGTH—.6430 MICRONS.



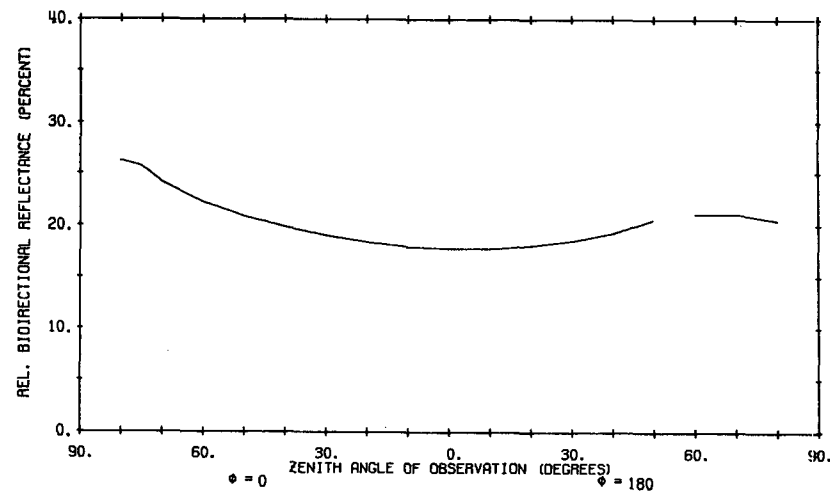
B09010 039

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.7960 MICRONS.



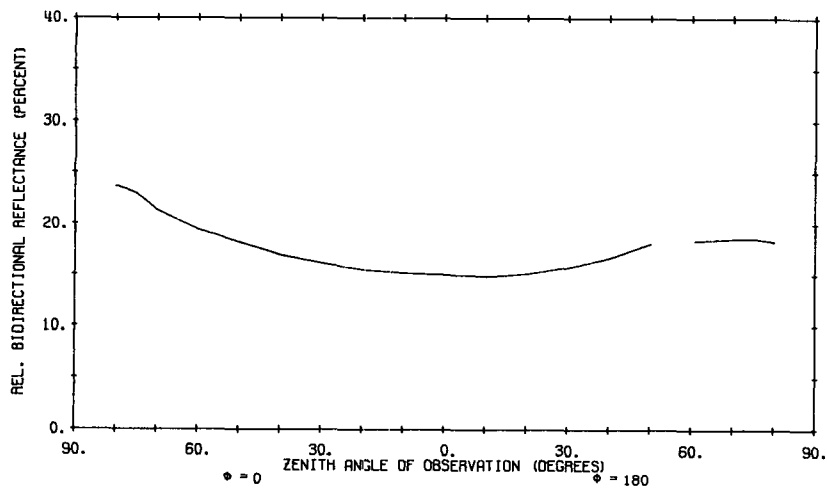
B09010 040

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.6430 MICRONS.



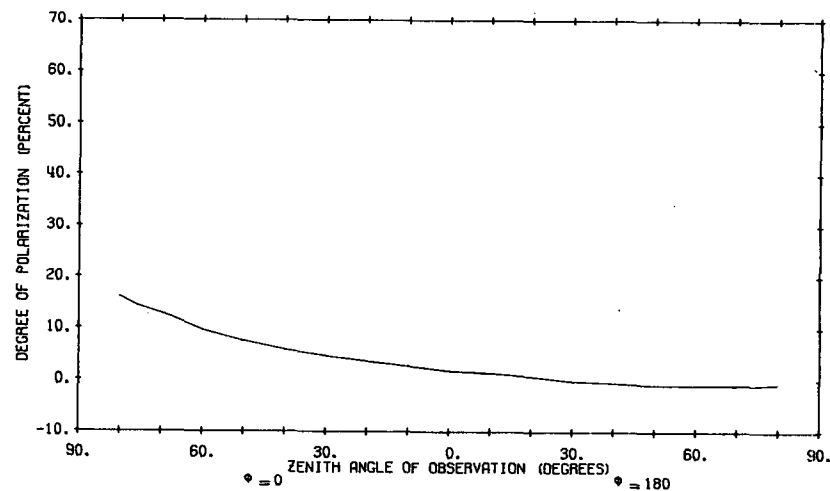
B09010 041

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.4920 MICRONS.



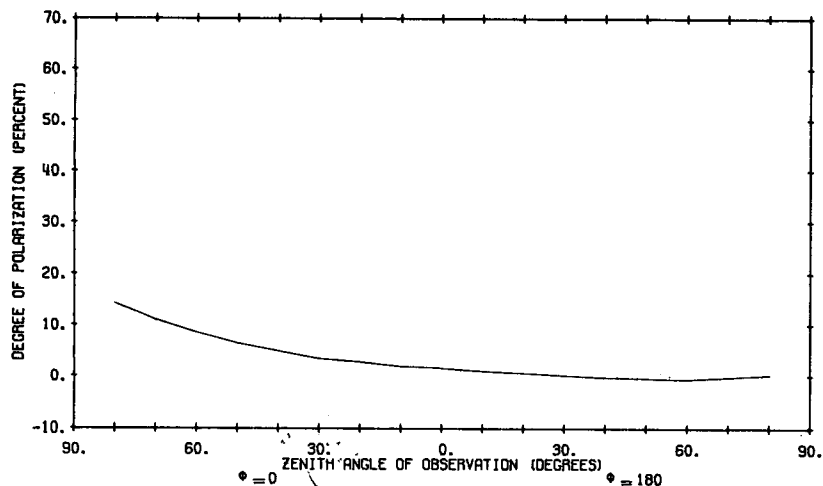
B09010 042

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.4920 MICRONS.



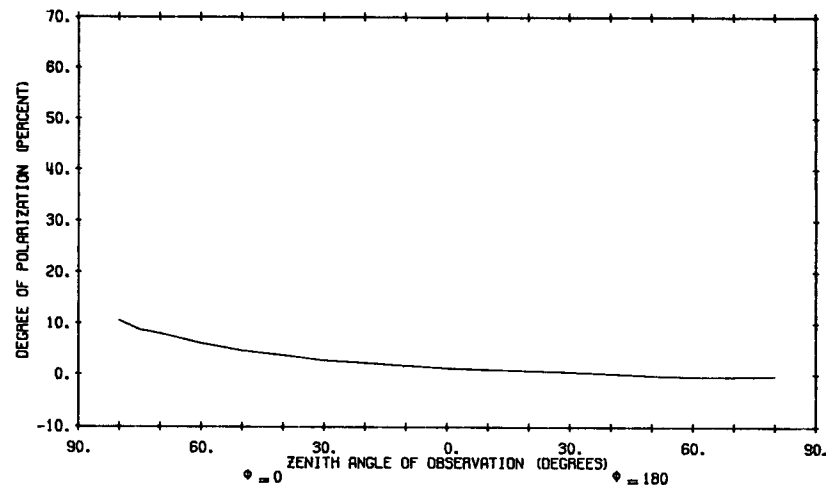
B09010 043

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.6430 MICRONS.



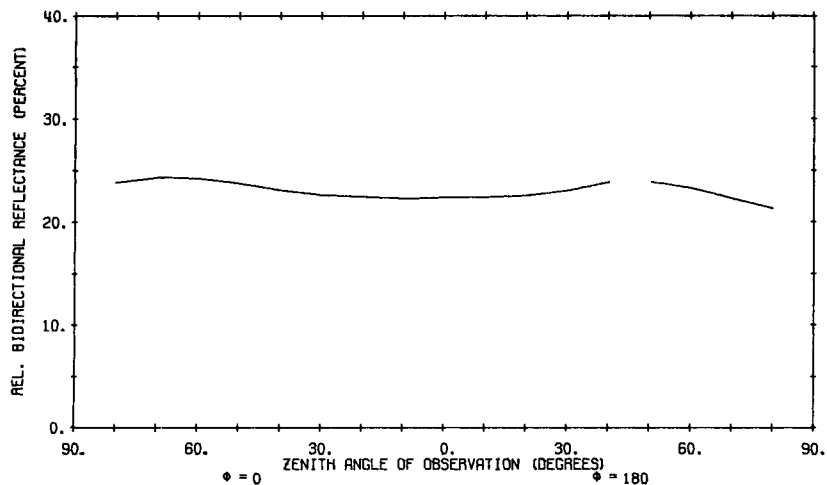
B09010 044

WHITE QUARTZ SAND (DAYTONA BEACH, FLORIDA), ANGLE OF INCIDENCE—53 DEG., WAVELENGTH—.7960 MICRONS.



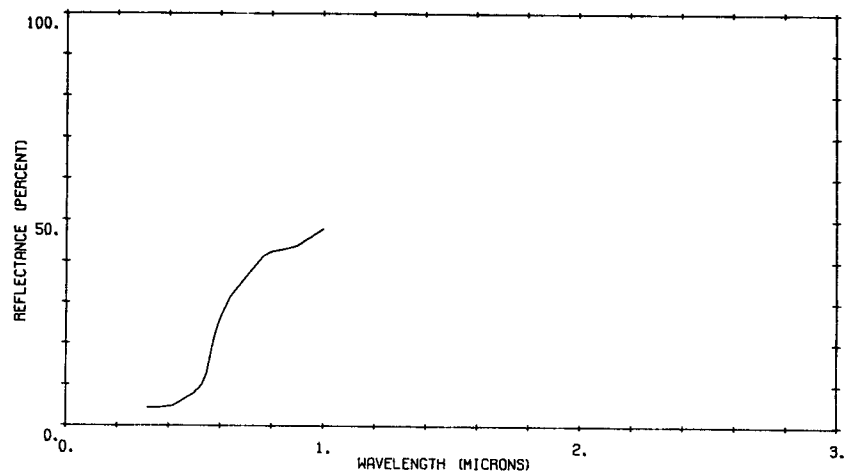
B09010 045

WHITE GYPSUM SAND (WHITE SANDS NATIONAL MONUMENT, N.M.), ANGLE OF INCIDENCE—60 DEG., WAVELENGTH—.5200 MICRONS.



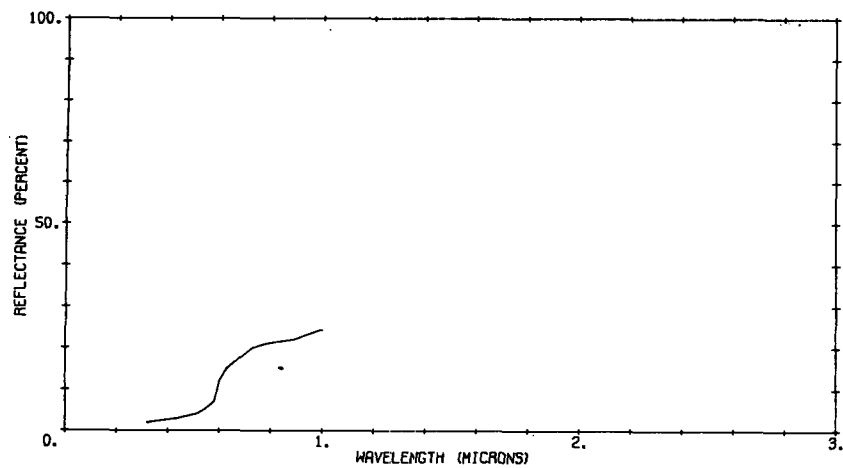
B09011 005

RED QUARTZ AND CALCITE SAND (MONUMENT VALLEY, UTAH), DRY.



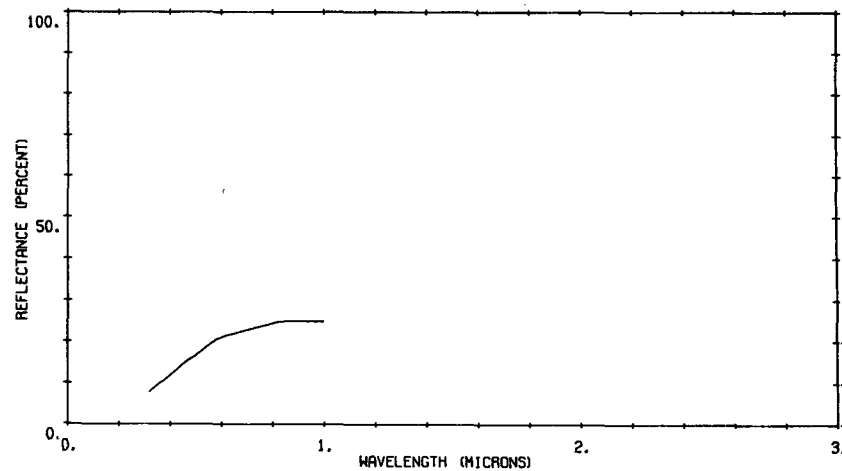
B09011 006

RED QUARTZ AND CALCITE SAND (MONUMENT VALLEY, UTAH), WET.



B09011 013

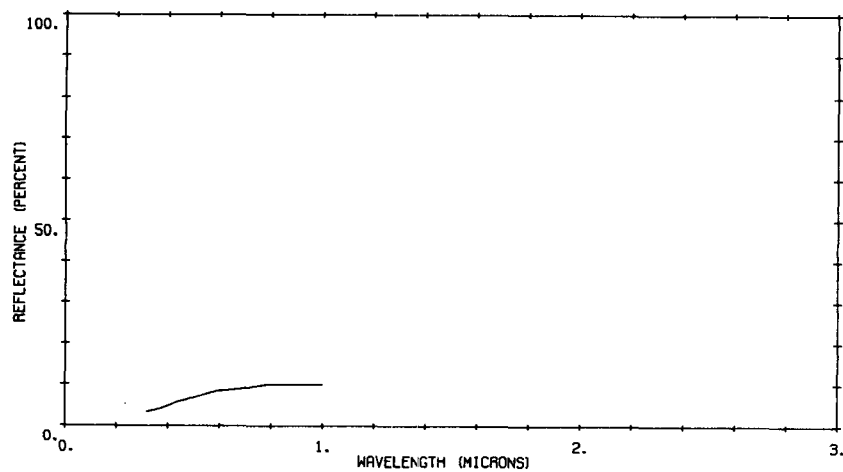
QUARTZ AND ROCK-FRAGMENT SAND (SNAKE RIVER AT COPPER MT. IN HELL'S CANYON), DRY.



BFCA 6

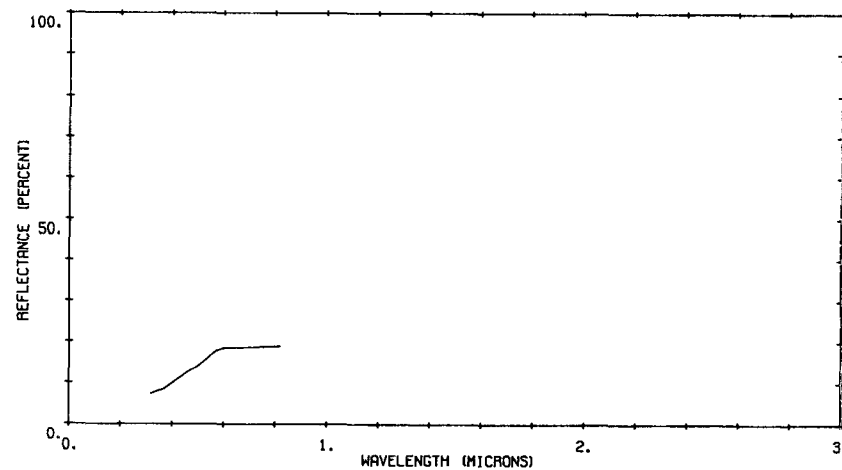
37 B09011 014

QUARTZ AND ROCK-FRAGMENT SAND (SNAKE RIVER AT COPPER MT. IN HELL'S CANYON), WET.



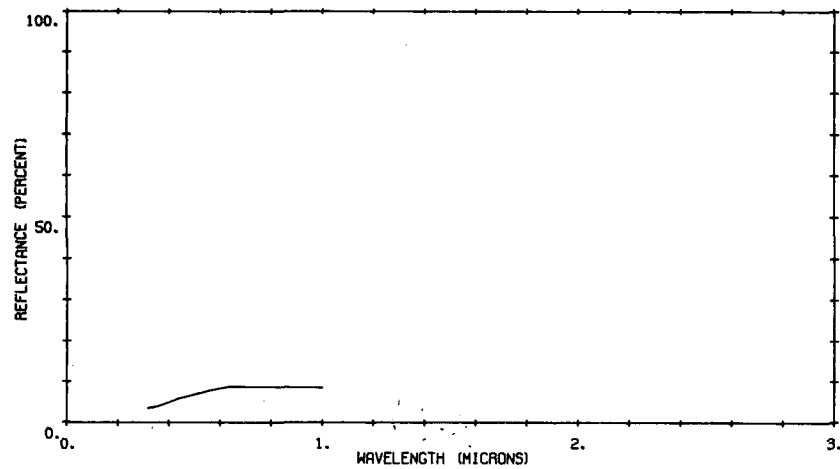
B09011 017

SAND CONTAINING QUARTZ, ROCK FRAGMENTS, AND SHELL FRAGMENTS (PUBLIC BEACH, NEWPORT, RHODE ISLAND), DRY.



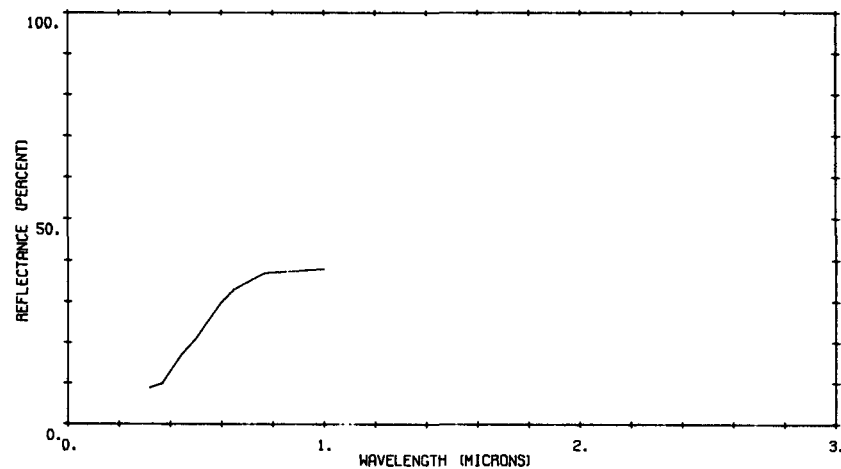
B09011 018

SAND CONTAINING QUARTZ, ROCK FRAGMENTS, AND SHELL FRAGMENTS  
(PUBLIC BEACH, NEWPORT, RHODE ISLAND), WET.



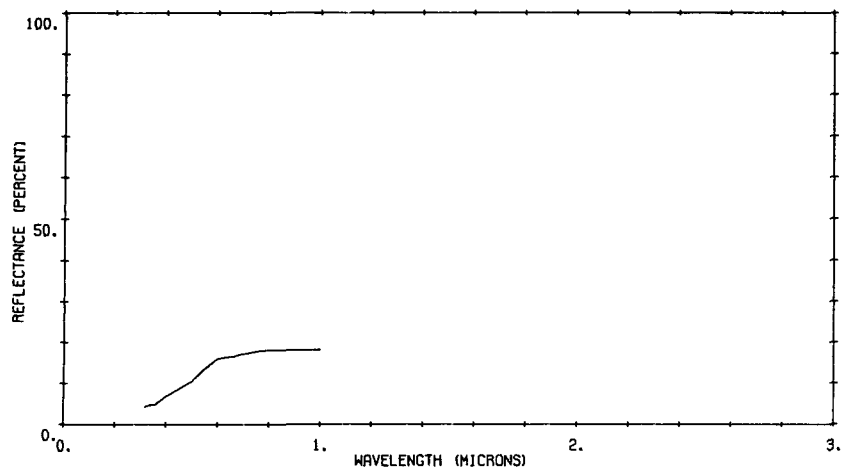
B09011 019

QUARTZ AND ROCK FRAGMENT SAND (PACIFIC OCEAN, SANTA MONICA,  
CALIFORNIA), DRY.



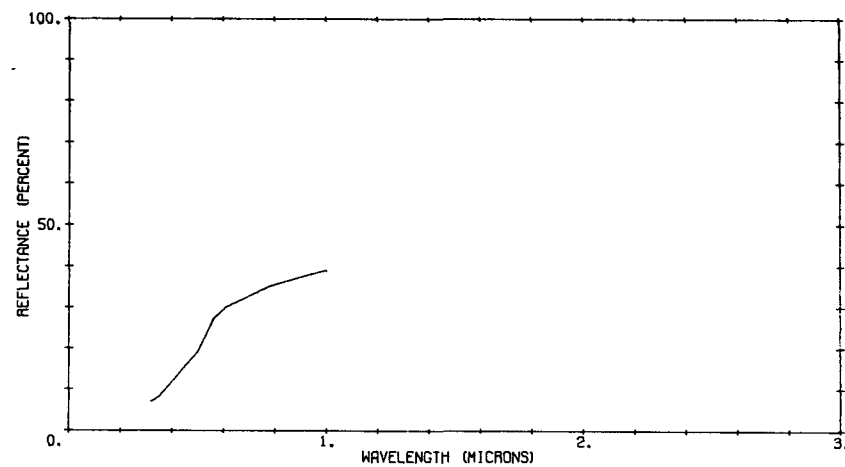
B09011 020

QUARTZ AND ROCK FRAGMENT SAND (PACIFIC OCEAN, SANTA MONICA,  
CALIFORNIA), WET.



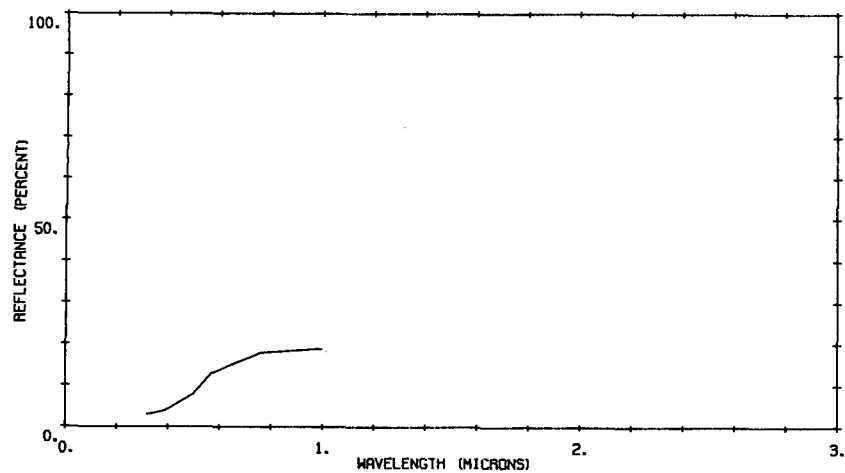
B09011 021

QUARTZ AND ROCK FRAGMENT SAND (COUSINS ISLAND IN CASCO BAY,  
MAINE), DRY.



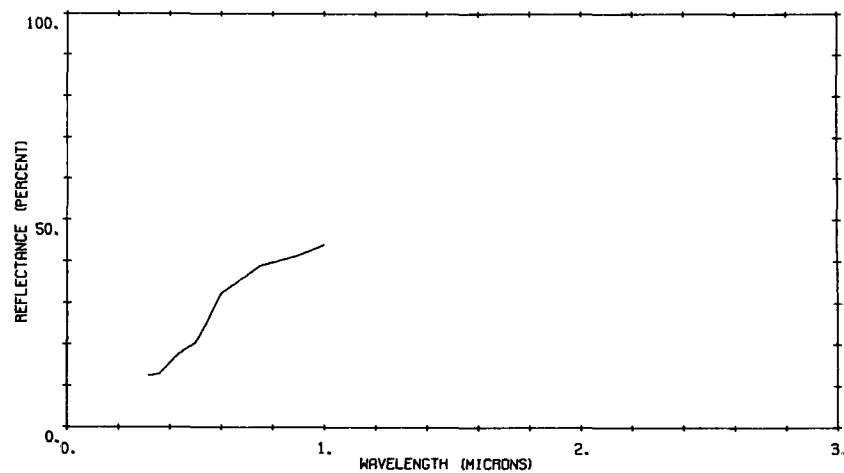
B09011 022

QUARTZ AND ROCK FRAGMENT SAND (COUSINS ISLAND IN CASCO BAY, MAINE), WET.



B09011 027

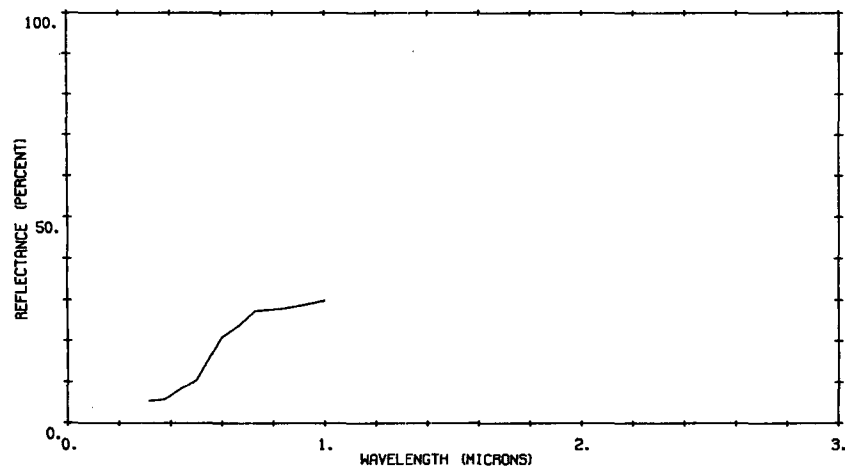
QUARTZ AND CARBONATE SAND (MIAMI BEACH, FLORIDA), DRY.



BICA 8

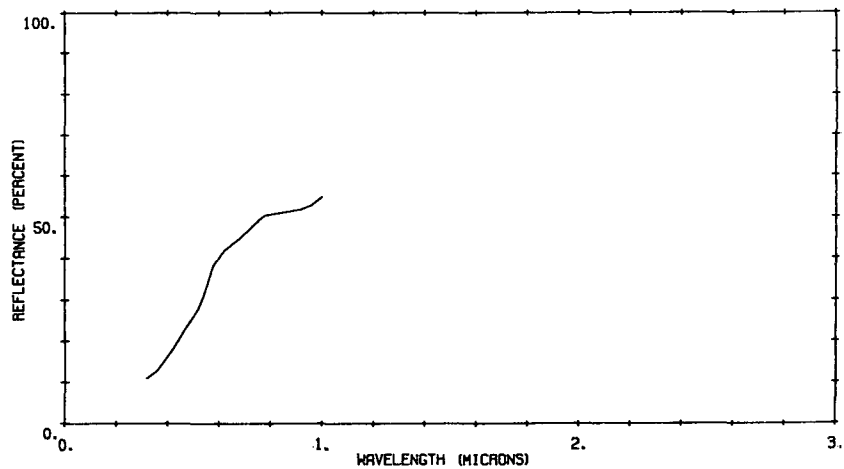
B09011 028

QUARTZ AND CARBONATE SAND (MIAMI BEACH, FLORIDA), WET.



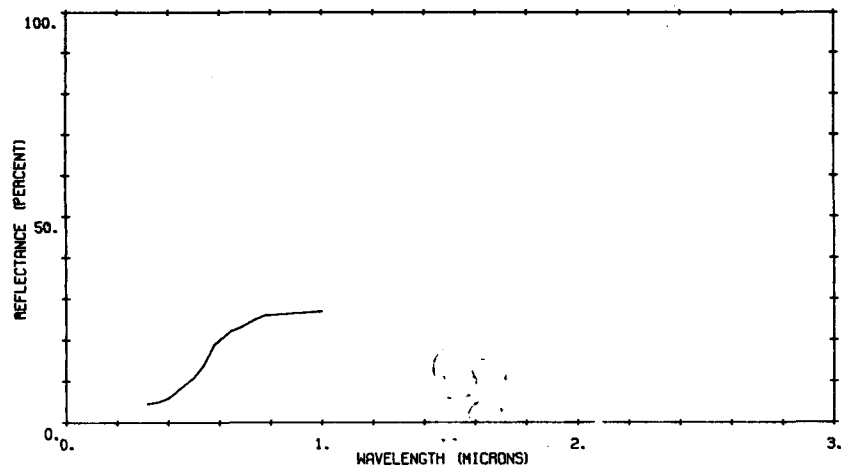
B09011 031

QUARTZ SAND (20 MI. N. OF COOS BAY, OREGON), DRY.



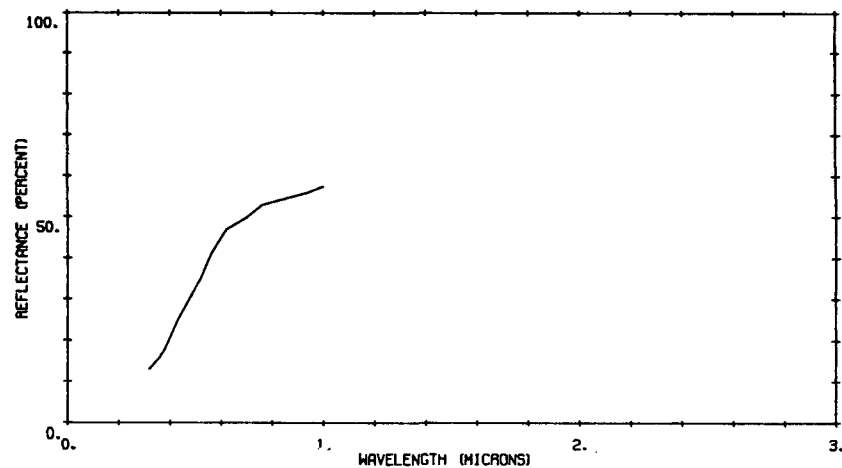
B09011 032

QUARTZ SAND (20 MI. N. OF COOS BAY, OREGON), WET.



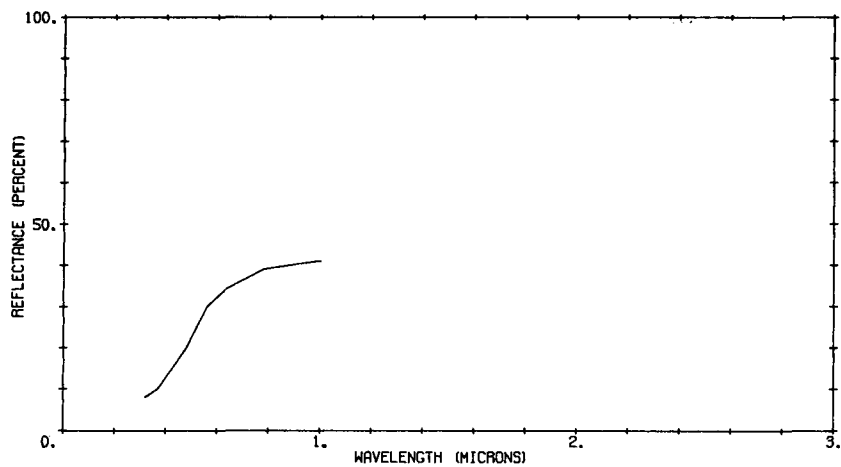
B09011 033

CARBONATE SAND (WAIKIKI BEACH, HONOLULU, HAWAII), DRY.



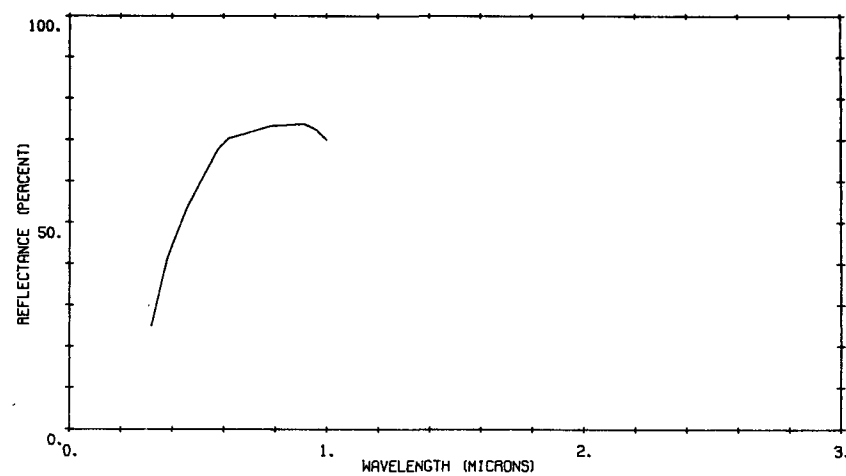
B09011 034

CARBONATE SAND (WAIKIKI BEACH, HONOLULU, HAWAII), WET.



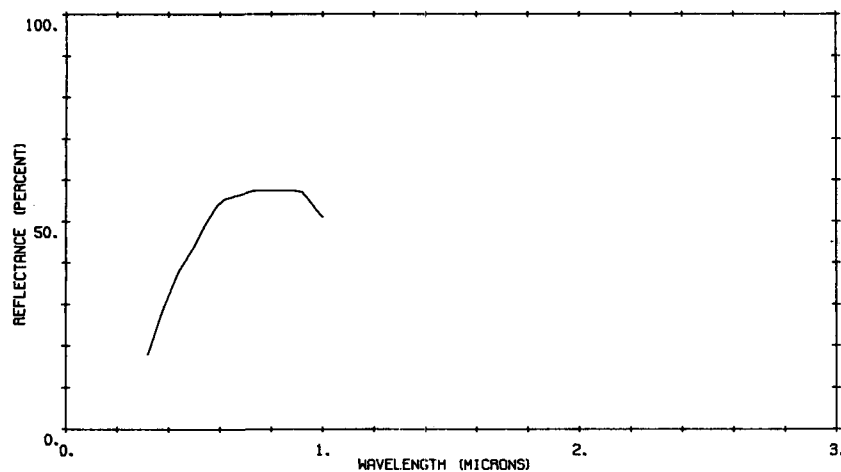
B09011 037

GYPSON SAND (WHITE SANDS NATIONAL MONUMENT, NEW MEX.), DRY.



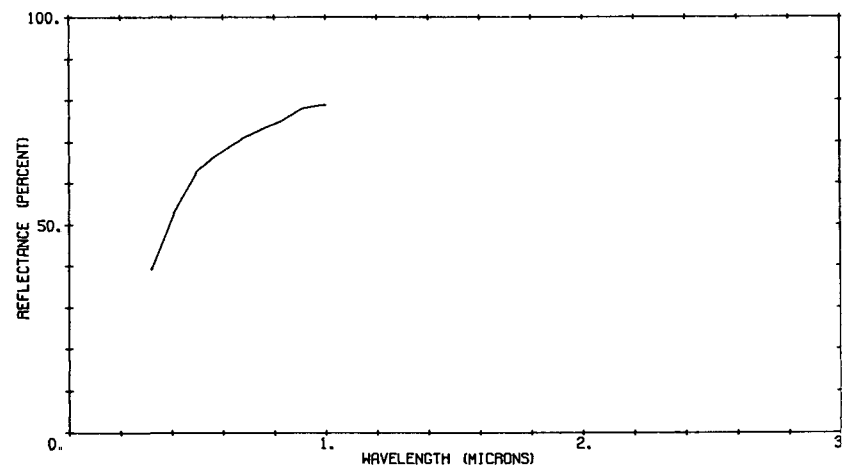
B09011 038

GYPSUM SAND (WHITE SANDS NATIONAL MONUMENT, NEW MEX.), WET.



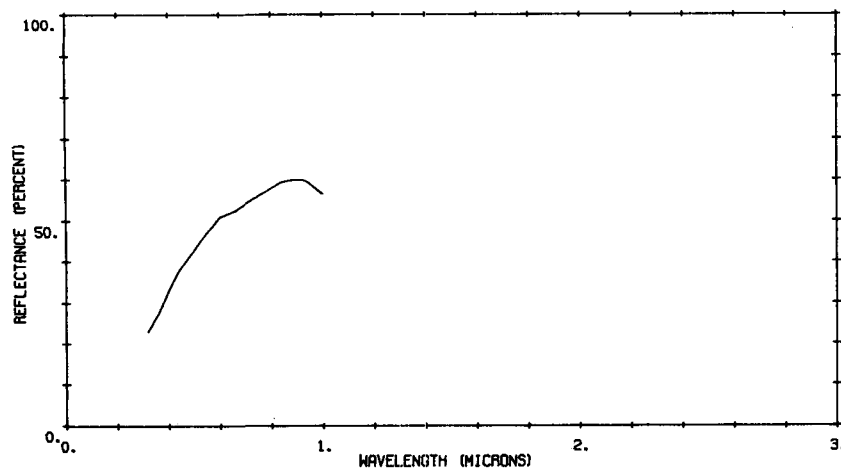
B09011 043

QUARTZ SAND (FT. WALTON BEACH, FLORIDA), DRY.



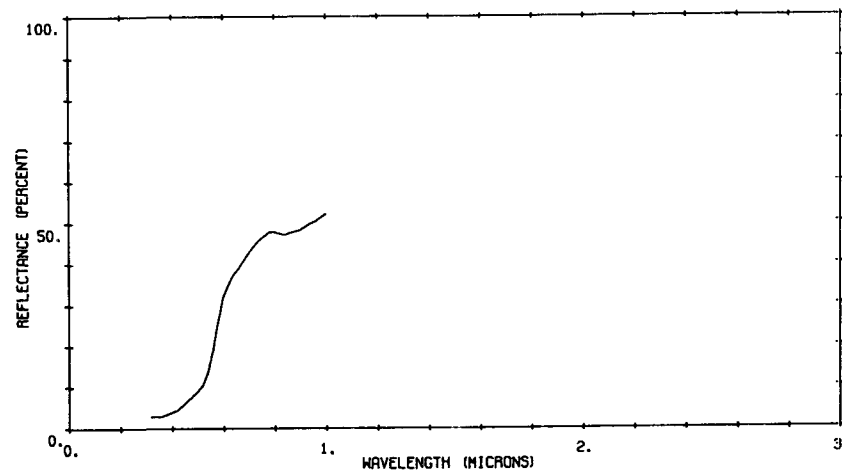
117  
B09011 044

QUARTZ SAND (FT. WALTON BEACH, FLORIDA), WET.



B09011 059

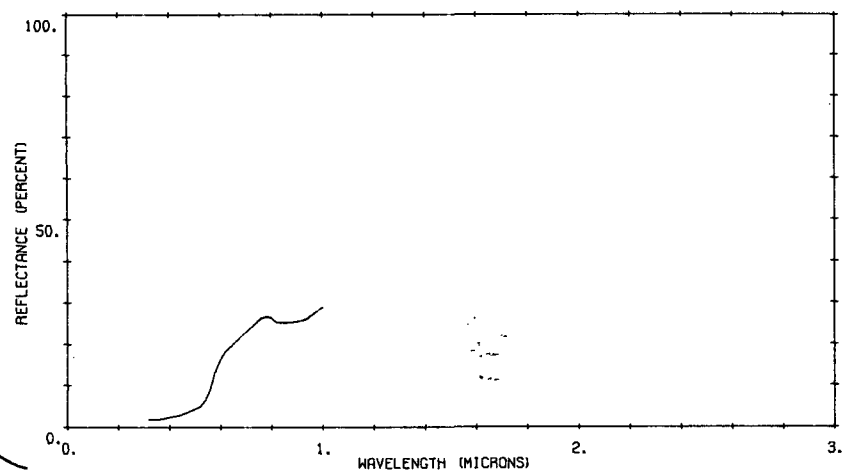
QUARTZ SAND WITH A HEMATITE SATIN (BOK TOWER, FLORIDA), DRY.





B09011 060

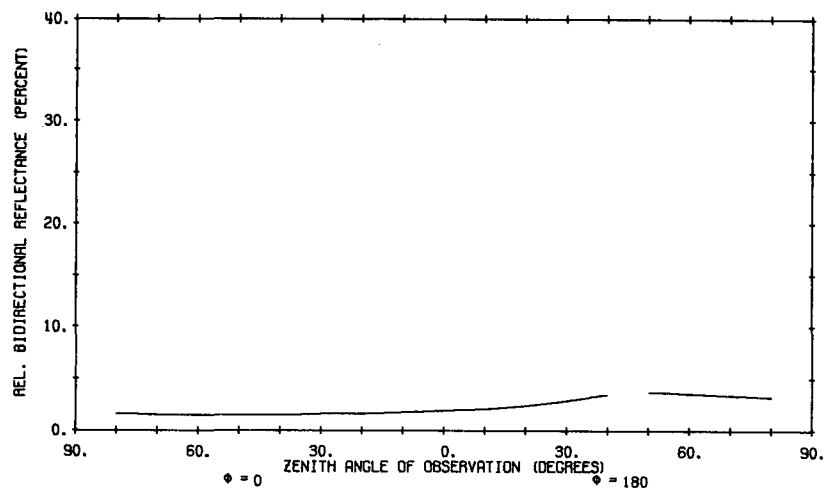
QUARTZ SAND WITH A HEMATITE SATIN (BOK TOWER, FLORIDA), WET.



BFEA  
LOAM

B09010 046

BLACK LOAM SOIL (MT. AYR, IOWA), ANGLE OF INCIDENCE—60 DEG.  
WAVELENGTH—.5200 MICRONS.

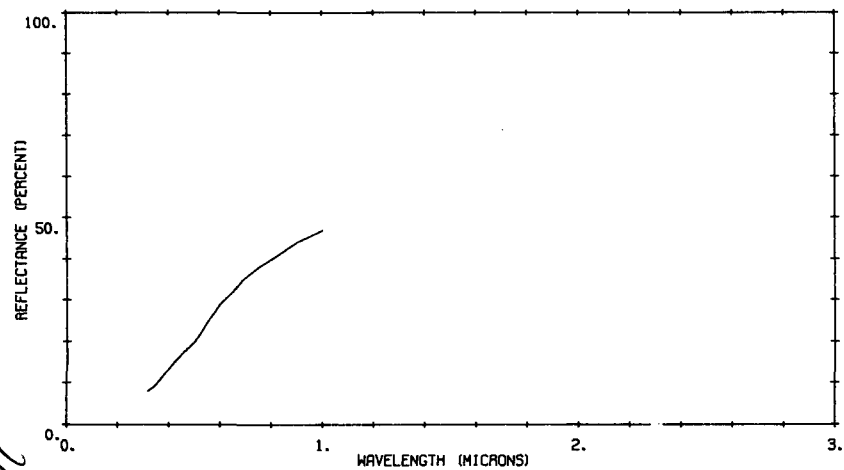


BFEC  
SILT

45

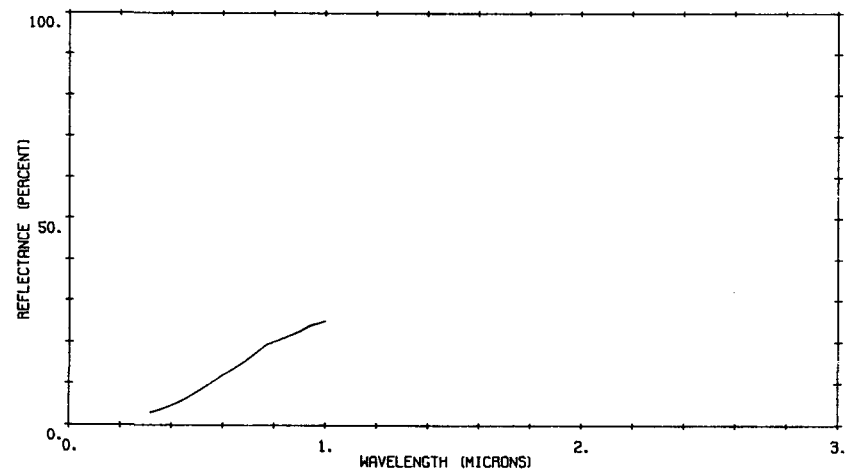
B09011 003

PEDALFER-TYPE SILT (15 MI. S.E. OF HOT SPRINGS, ARK.), DRY.



B09011 004

PEDALFER-TYPE SILT (15 MI. S. E. OF HOT SPRINGS, ARK.), WET.

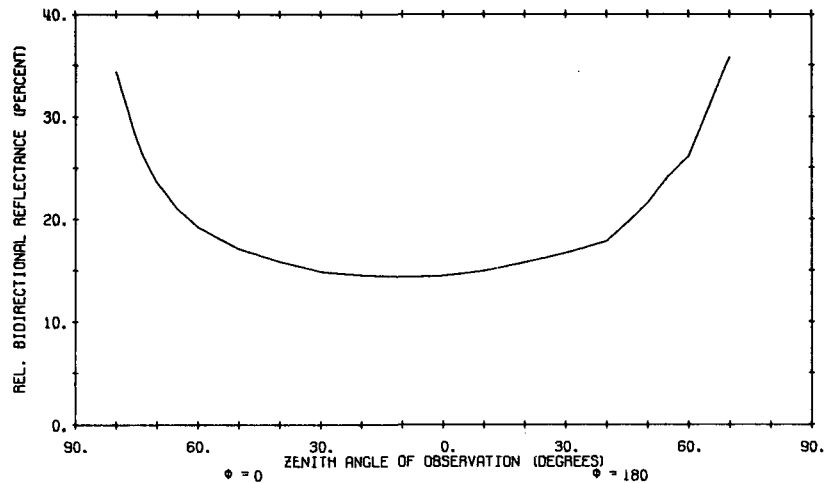


BFGC  
CLAY

47

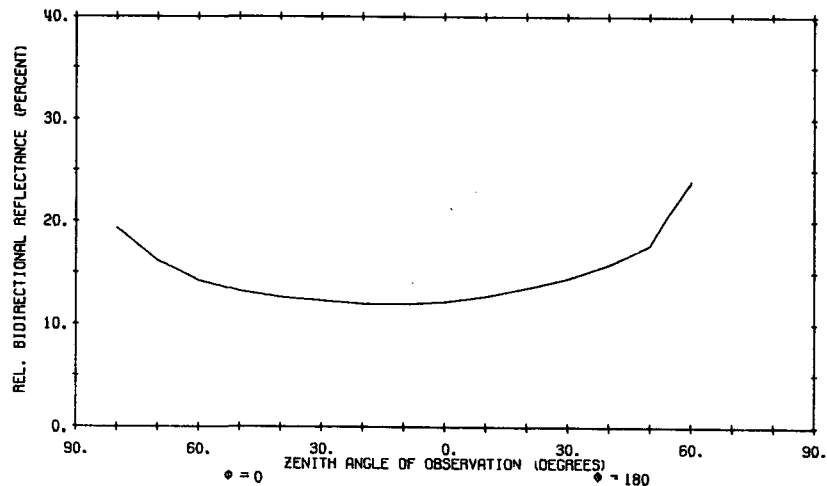
B09010 001

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
78 DEG., WAVELENGTH—.6430 MICRONS.



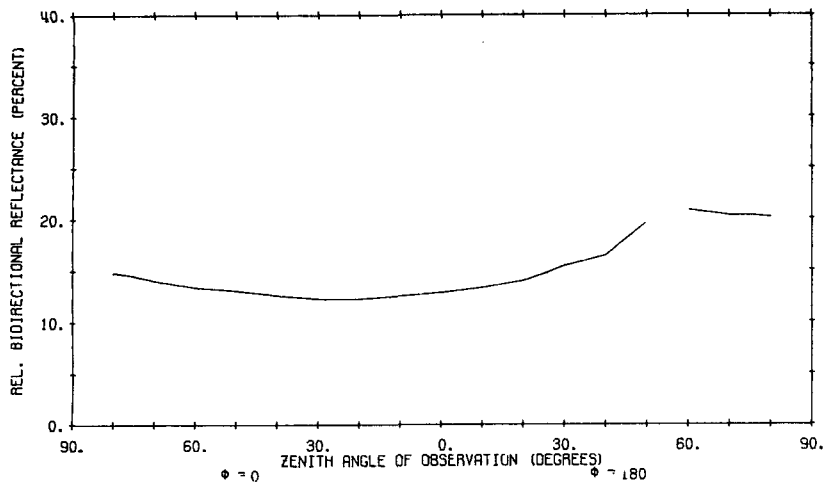
B09010 002

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
66 DEG., WAVELENGTH—.6430 MICRONS.



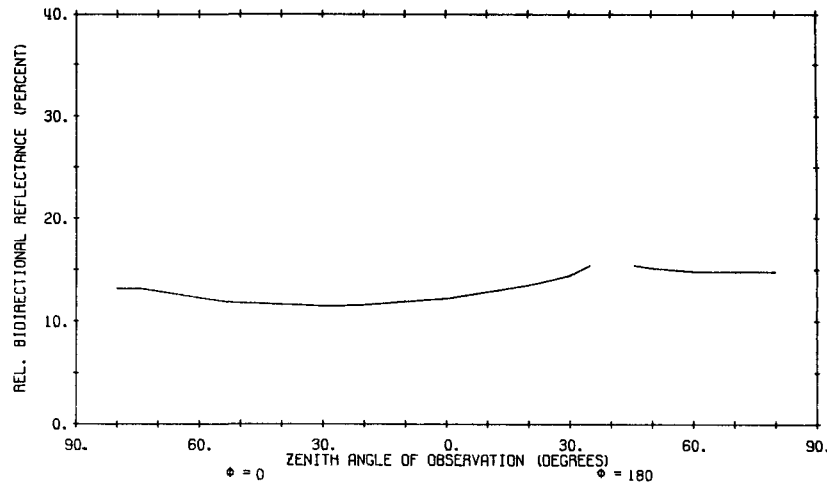
B09010 003

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
53 DEG., WAVELENGTH—.6430 MICRONS.



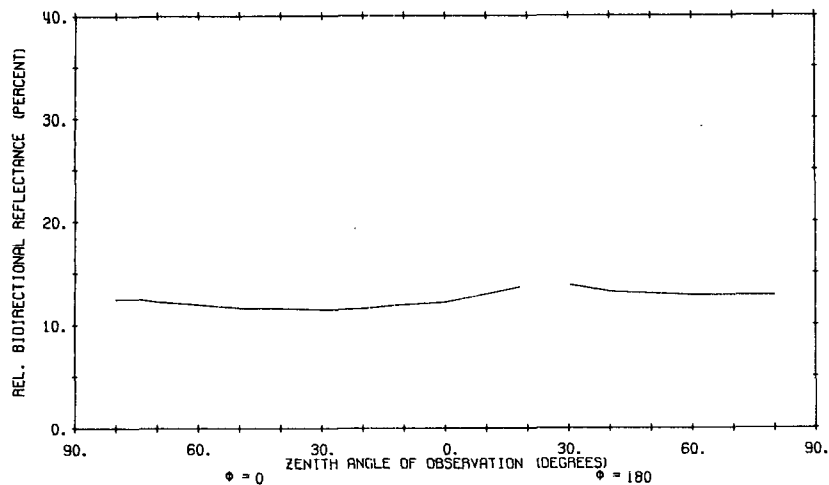
B09010 004

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
37 DEG., WAVELENGTH—.6430 MICRONS.



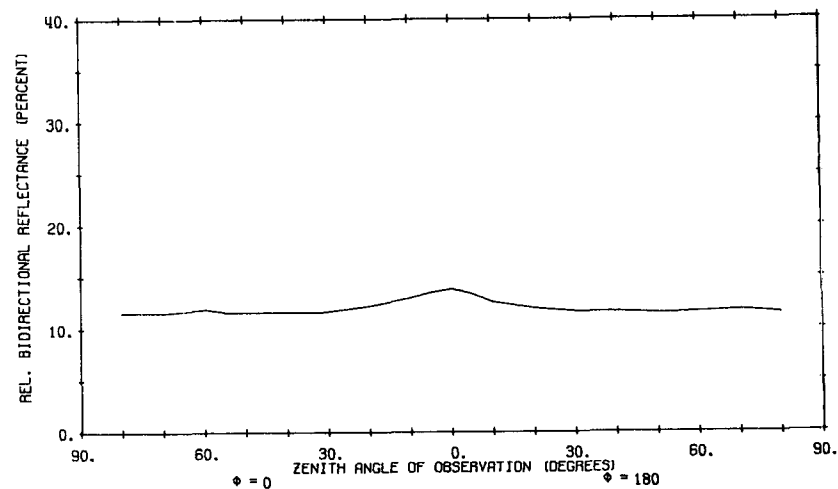
B09010 005

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
23 DEG., WAVELENGTH—.6430 MICRONS.



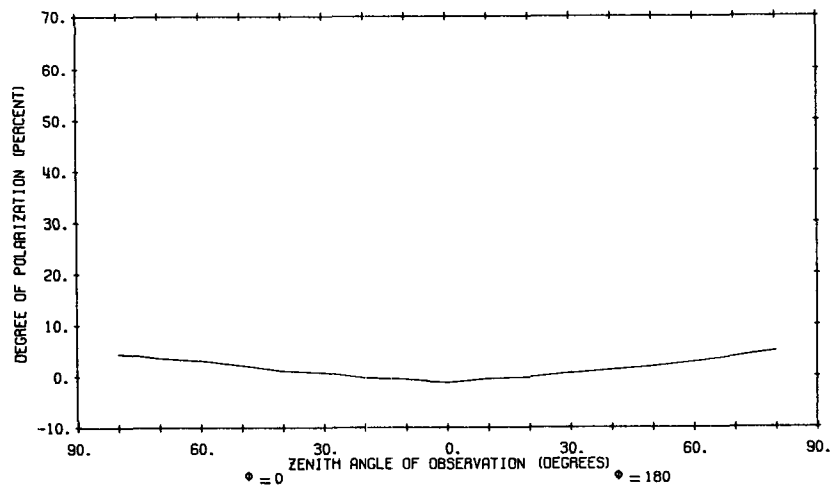
B09010 006

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
0 DEG., WAVELENGTH—.6430 MICRONS.



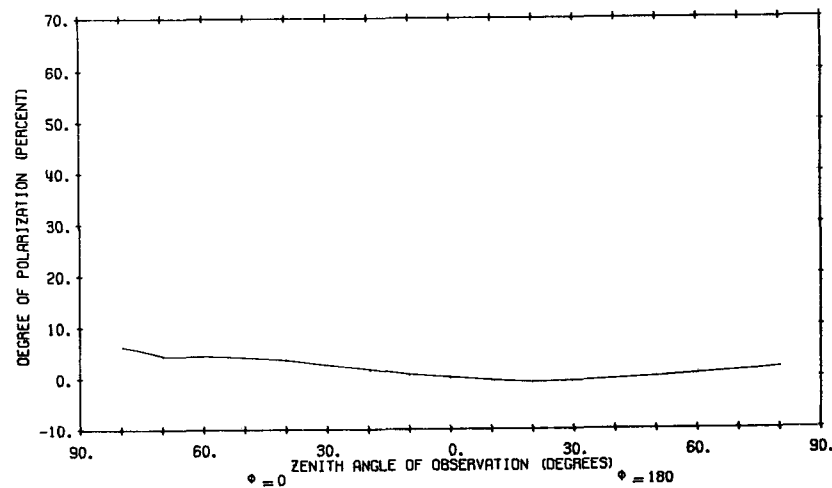
B09010 007

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
0 DEG., WAVELENGTH—.6430 MICRONS.



B09010 008

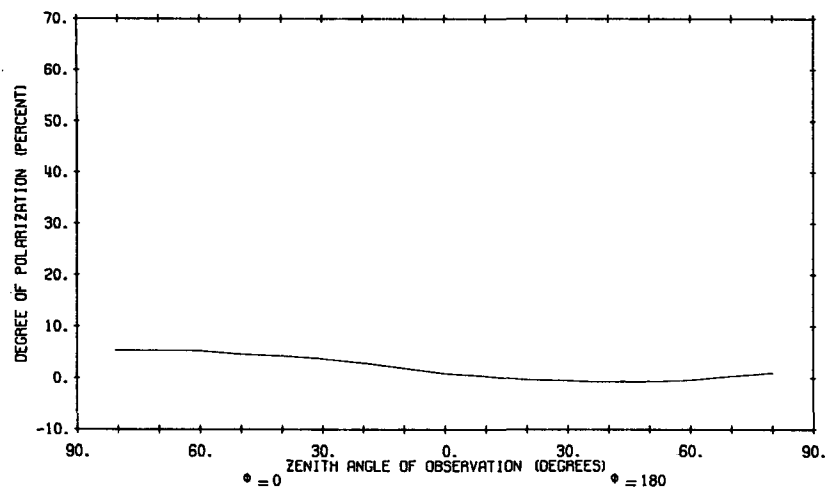
RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
23 DEG., WAVELENGTH—.6430 MICRONS.





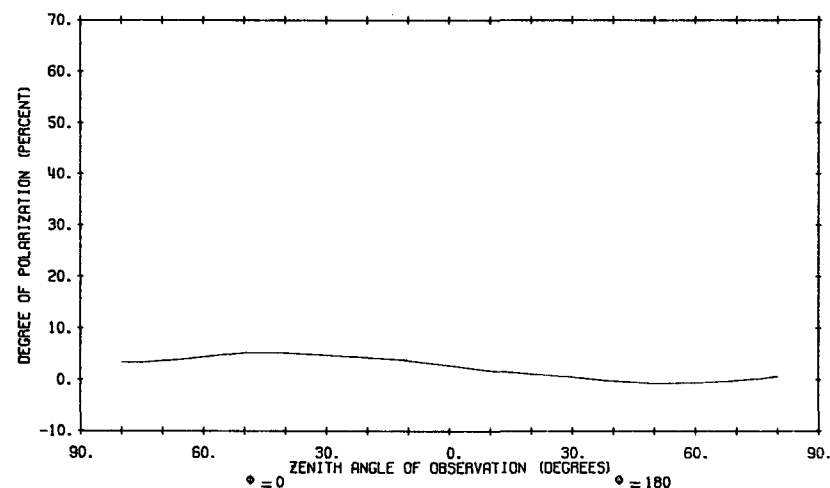
B09010 009

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
37 DEG., WAVELENGTH—.6430 MICRONS.



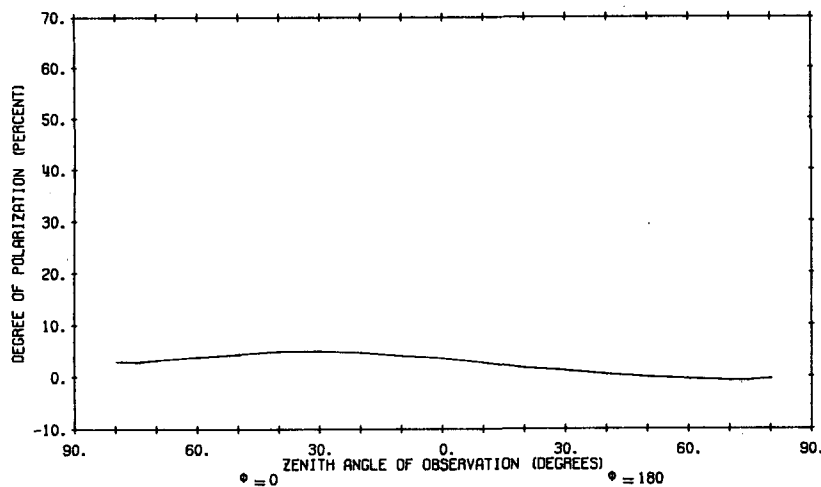
B09010 010

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
53 DEG., WAVELENGTH—.6430 MICRONS.



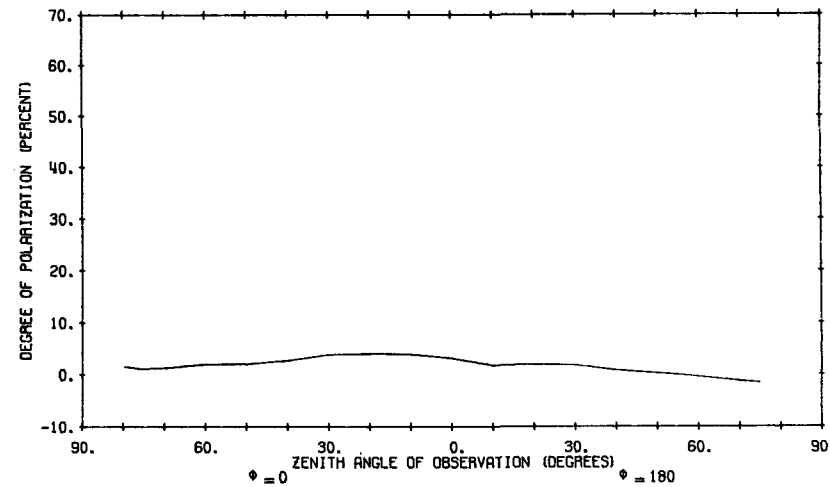
B09010 011

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
67 DEG., WAVELENGTH—.6430 MICRONS.



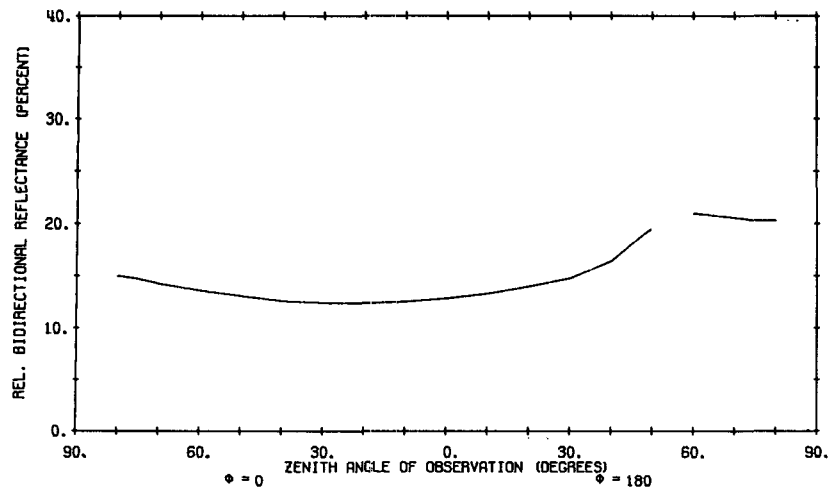
B09010 012

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—  
78 DEG., WAVELENGTH—.6430 MICRONS.



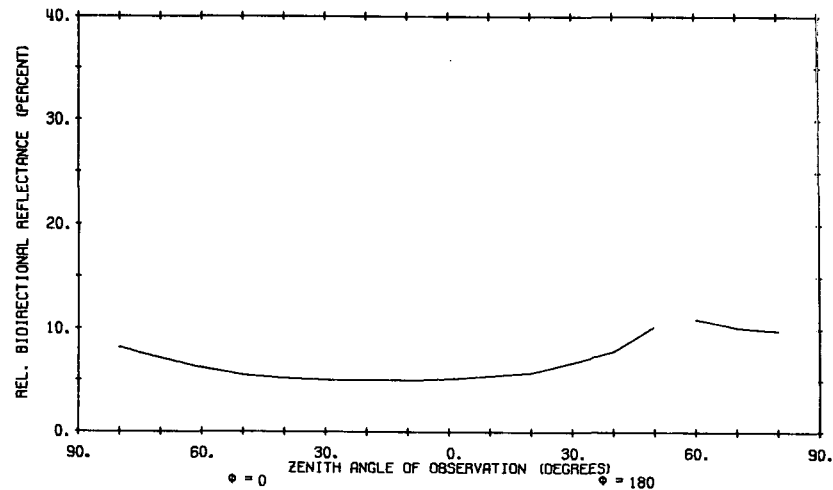
B09010 013

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
53 DEG., WAVELENGTH—.6430 MICRONS.



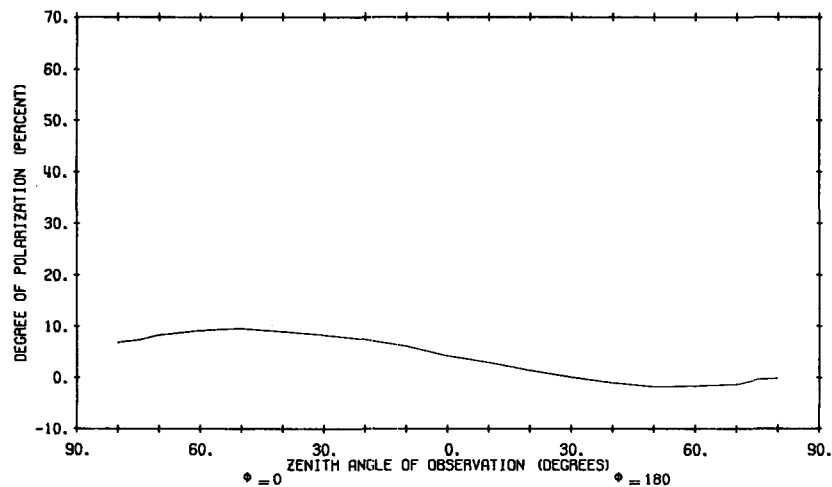
B09010 014

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
53 DEG., WAVELENGTH—.4920 MICRONS.



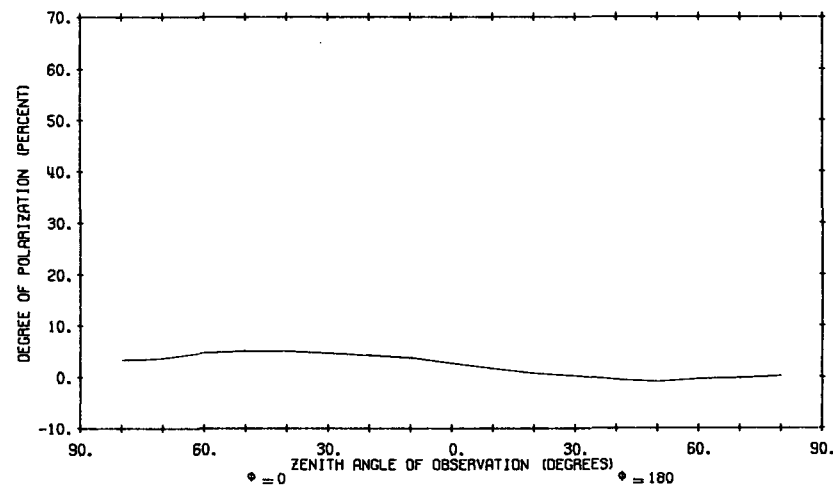
B09010 015

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
53 DEG., WAVELENGTH—.4920 MICRONS.



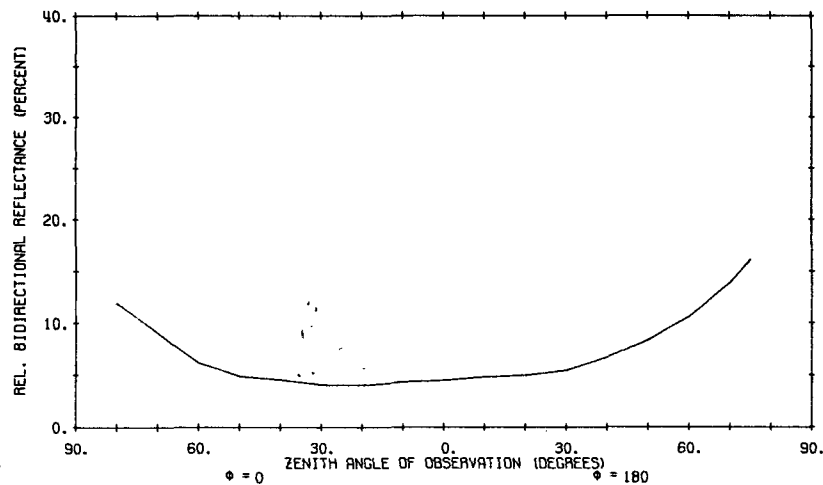
B09010 016

RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE —  
53 DEG., WAVELENGTH—.6430 MICRONS.



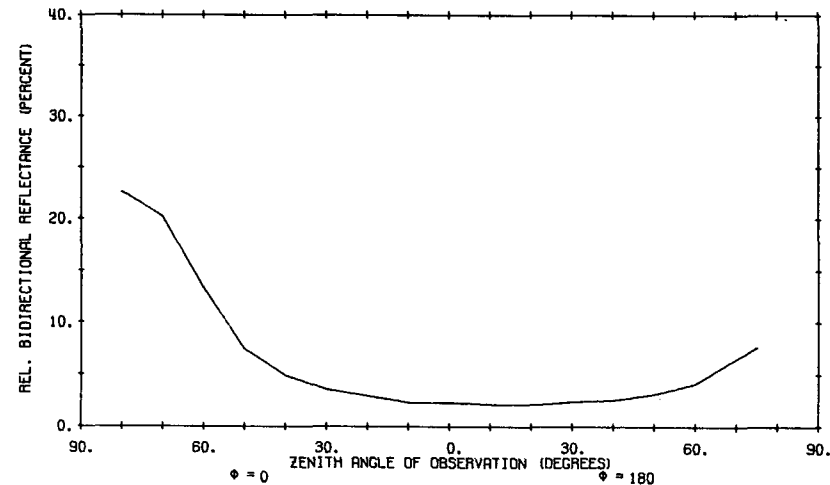
B09010 017

DRY RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—80 DEG., WAVELENGTH—.5200 MICRONS.



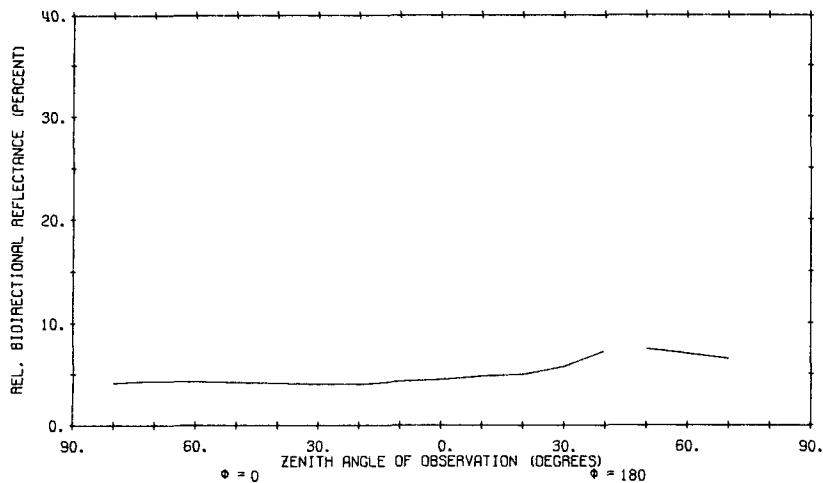
B09010 018

WET RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—80 DEG., WAVELENGTH—.5200 MICRONS.



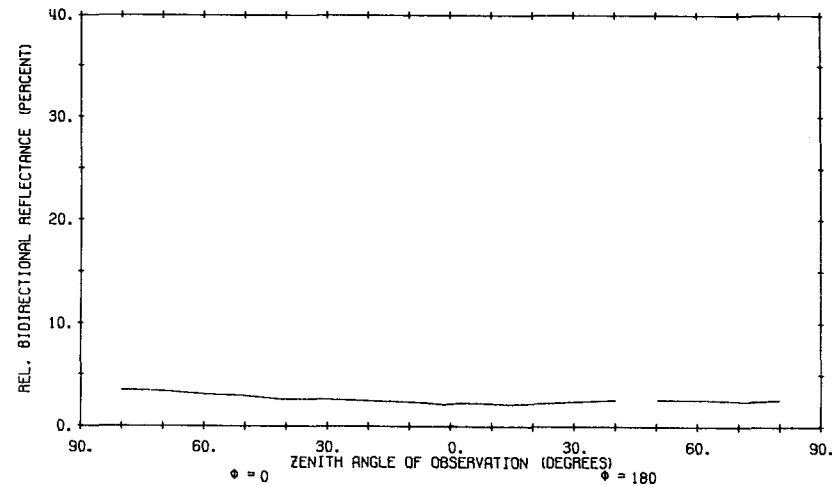
B09010 019

DRY RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—45 DEG., WAVELENGTH—.5200 MICRONS.



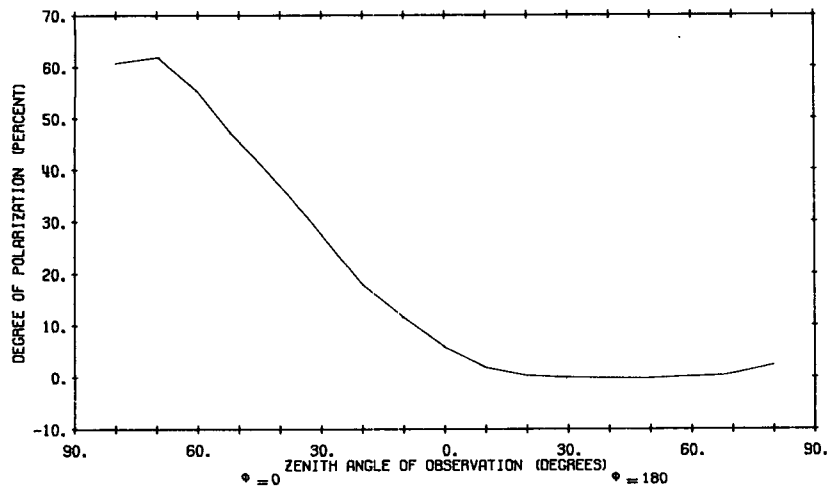
B09010 020

WET RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—45 DEG., WAVELENGTH—.5200 MICRONS.



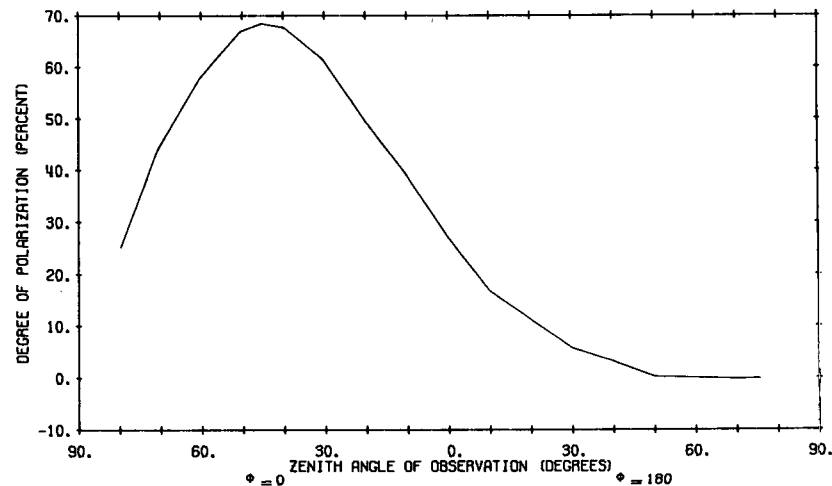
B09010 021

WET RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—45 DEG., WAVELENGTH—.5200 MICRONS.



B09010 022

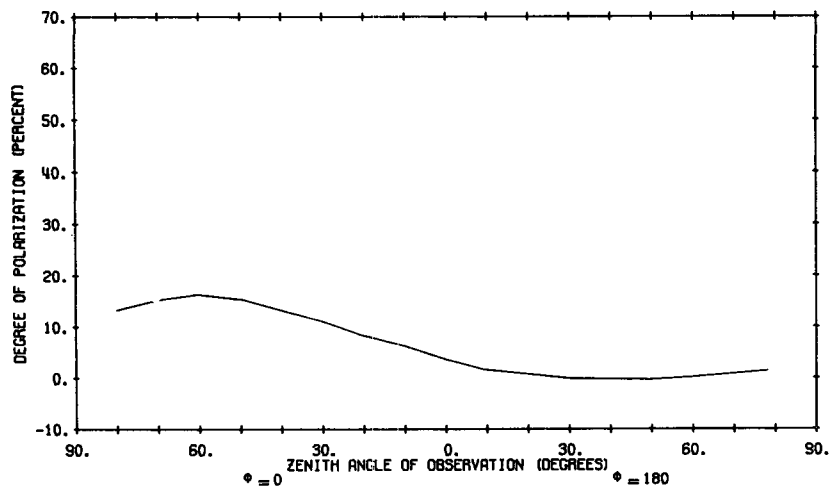
WET RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—80 DEG., WAVELENGTH—.5200 MICRONS.



BFGC 6

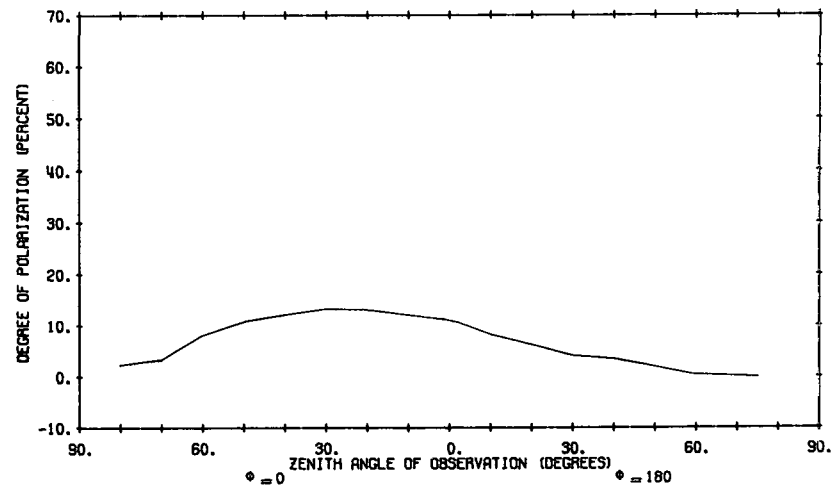
157  
63  
B09010 023

DRY RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—45 DEG., WAVELENGTH—.5200 MICRONS.



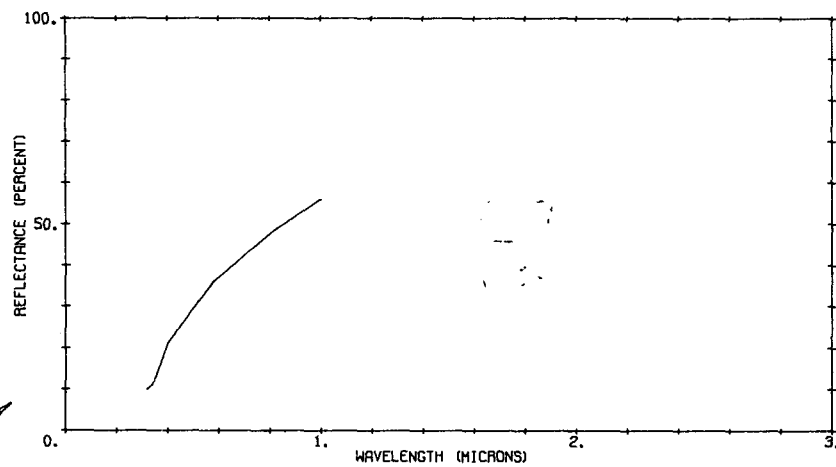
B09010 024

DRY RED CLAY (PHILADELPHIA, PENNSYLVANIA), ANGLE OF INCIDENCE—80 DEG., WAVELENGTH—.5200 MICRONS.



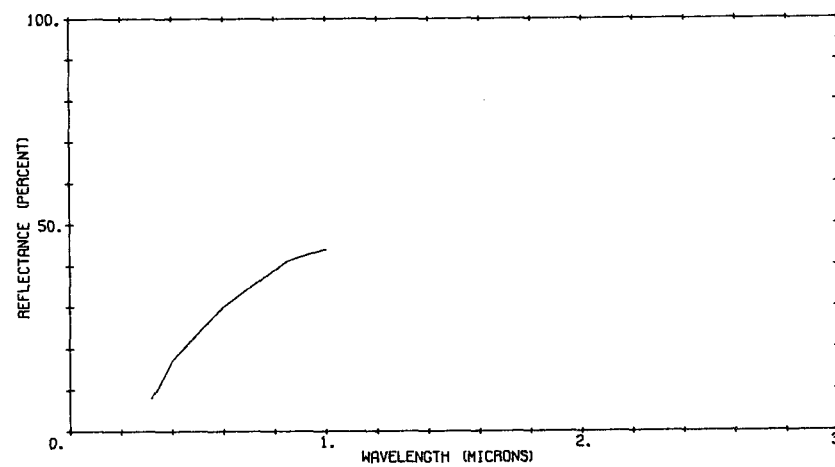
B09011 025

CLAY (3 MI. E. OF PARIS, MISSOURI), DRY.



B09011 026

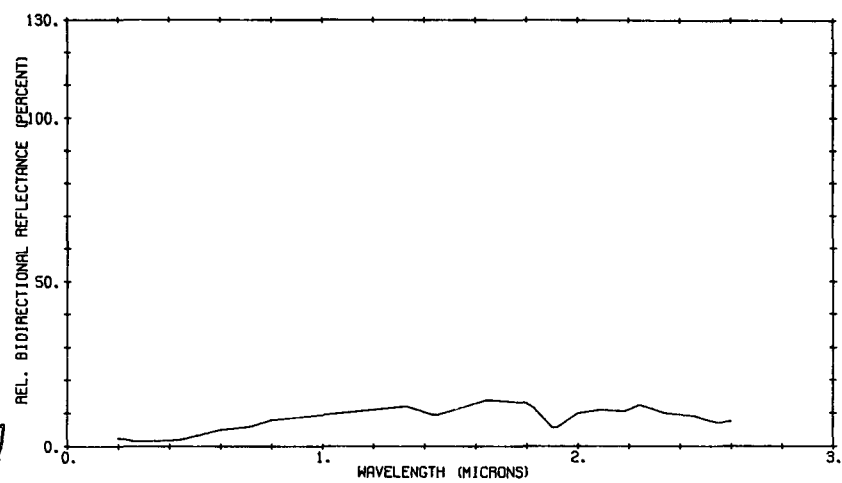
CLAY (3 MI. E. OF PARIS, MISSOURI), WET



BFHA  
ORGANIC MATERIAL

B09004 012

MOIST HUMUS SOIL.

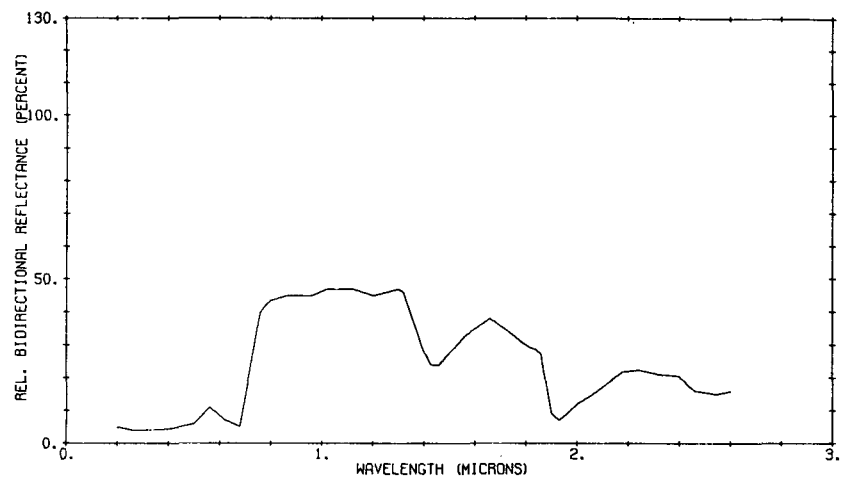


BGCM  
GRASS FAMILY



B09004 007

COARSE GRASS.



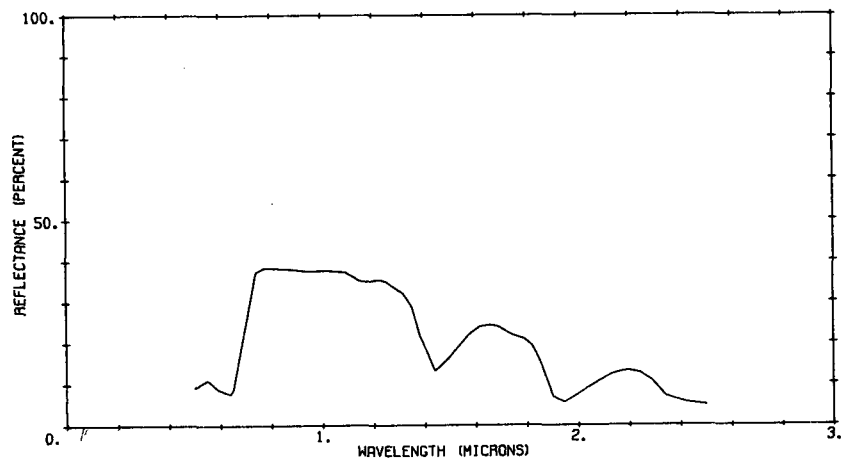
58

BGCOA  
COTTON

C-2

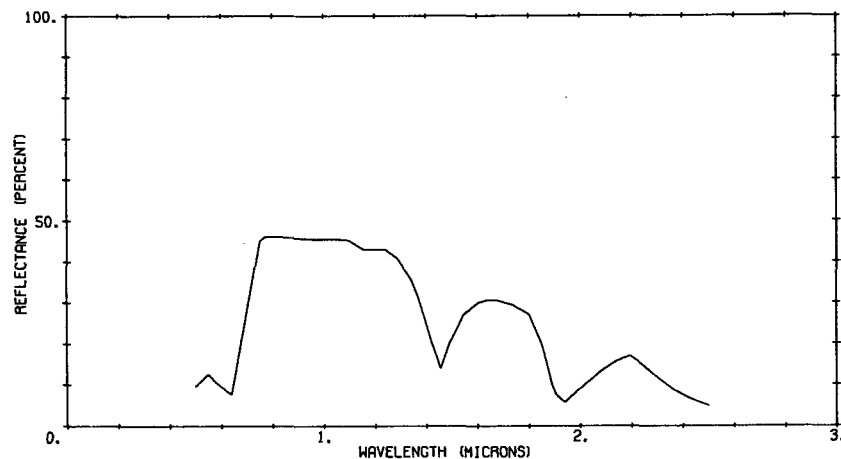
B09013 001

COTTON LEAF (GOSSYPIMUM HIRSUTUM) FROM RAYMONDVILLE, TEXAS  
FIELD 20 DAYS AFTER EMERGENCE ON STEM, LEAF IN SECOND NODAL  
POSITION ON STEM AS MEASURED FROM THE PLANT APEX.



B09013 002

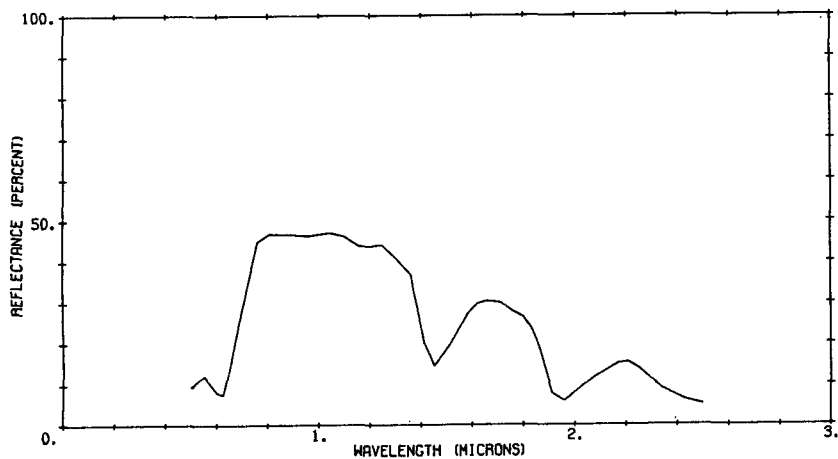
COTTON LEAF (GOSSYPIMUM HIRSUTUM) FROM RAYMONDVILLE, TEXAS  
FIELD 25 DAYS AFTER EMERGENCE ON STEM, LEAF IN THIRD NODAL  
POSITION ON STEM AS MEASURED FROM THE PLANT APEX.



60

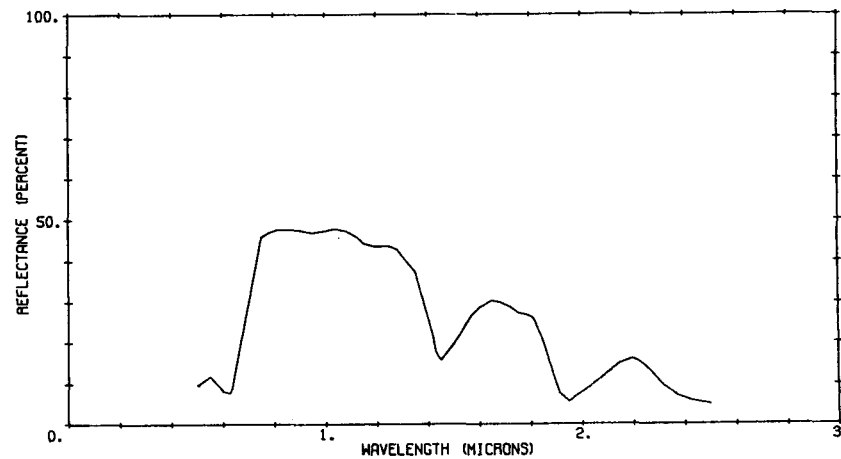
B09013 003

COTTON LEAF (GOSSYPIMUM HIRSUTUM) FROM RAYMONDVILLE, TEXAS  
FIELD 29 DAYS AFTER EMERGENCE ON STEM, LEAF IN FOURTH NODAL  
POSITION ON STEM AS MEASURED FROM THE PLANT APEX.



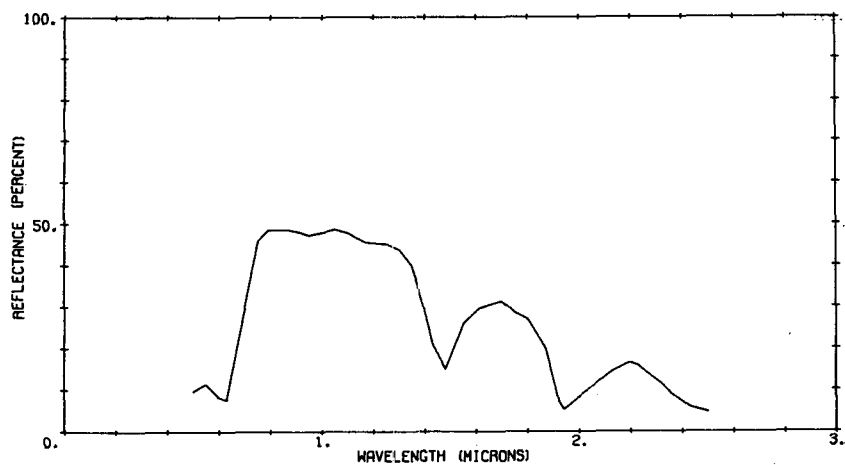
B09013 004

COTTON LEAF (GOSSYPIMUM HIRSUTUM) FROM RAYMONDVILLE, TEXAS  
FIELD 33 DAYS AFTER EMERGENCE ON STEM, LEAF IN FIFTH NODAL  
POSITION ON STEM AS MEASURED FROM THE PLANT APEX.



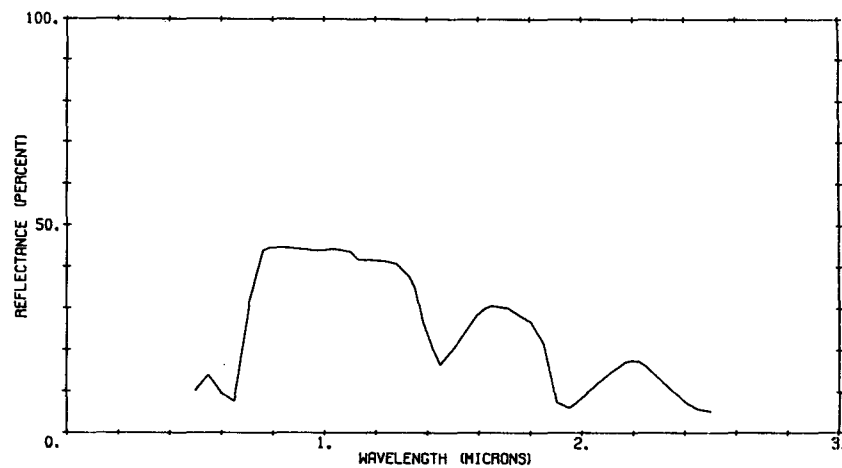
B09013 005

COTTON LEAF (GOSSYPIMUM HIRSUTUM) FROM RAYMONDVILLE, TEXAS  
FIELD 35 DAYS AFTER EMERGENCE ON STEM, LEAF IN SIXTH NODAL  
POSITION ON STEM AS MEASURED FROM THE PLANT APEX.



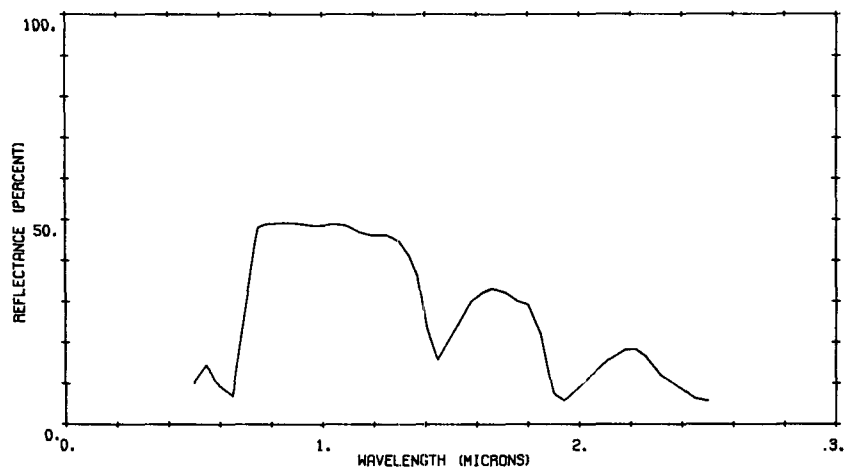
B09013 006

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN SECOND NODAL POSITION ON STEM AS MEASURED FROM THE PLANT  
APEX.



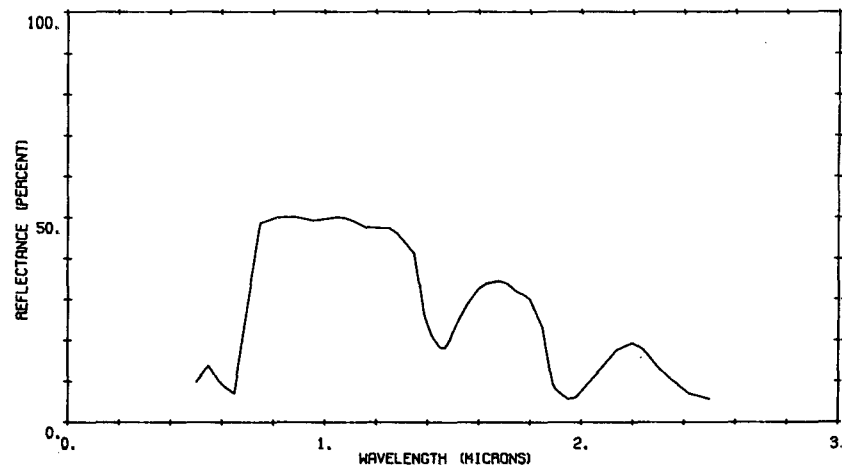
B09013 007

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN FOURTH NODAL POSITION ON STEM AS MEASURED FROM THE PLANT  
APEX.



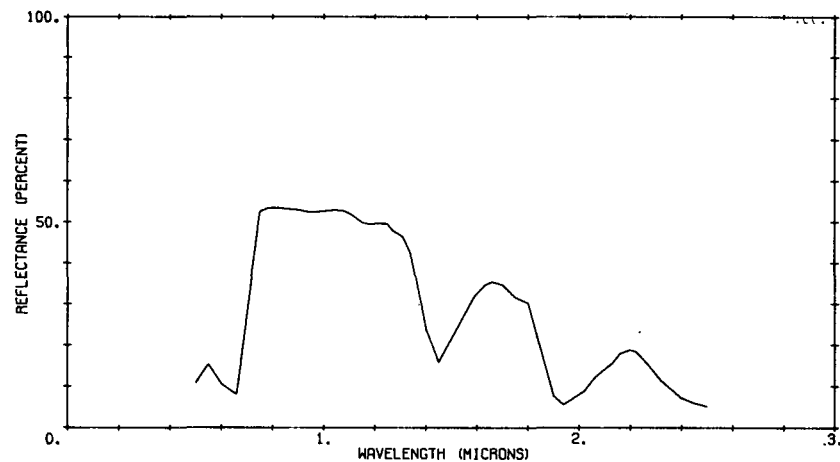
B09013 008

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN SIXTH NODAL POSITION ON STEM AS MEASURED FROM THE PLANT  
APEX.



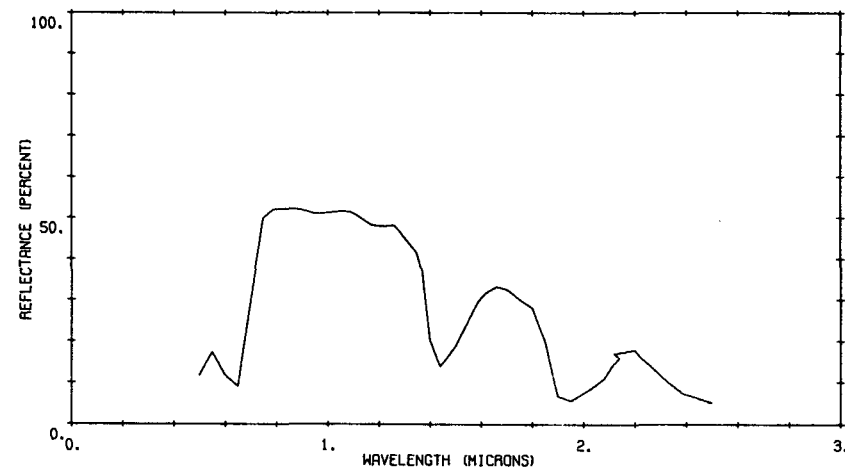
B09013 009

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN EIGHTH NODAL POSITION ON STEM AS MEASURED FROM THE PLANT  
APEX.



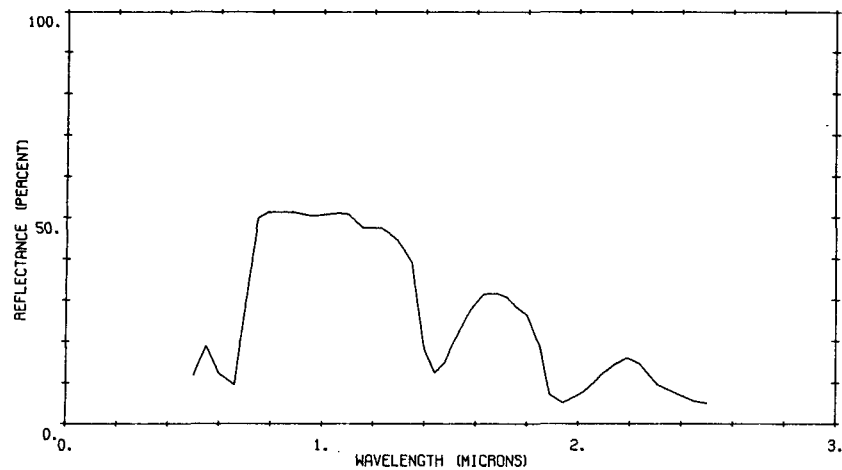
B09013 010

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN TENTH NODAL POSITION ON STEM AS MEASURED FROM THE PLANT  
APEX.



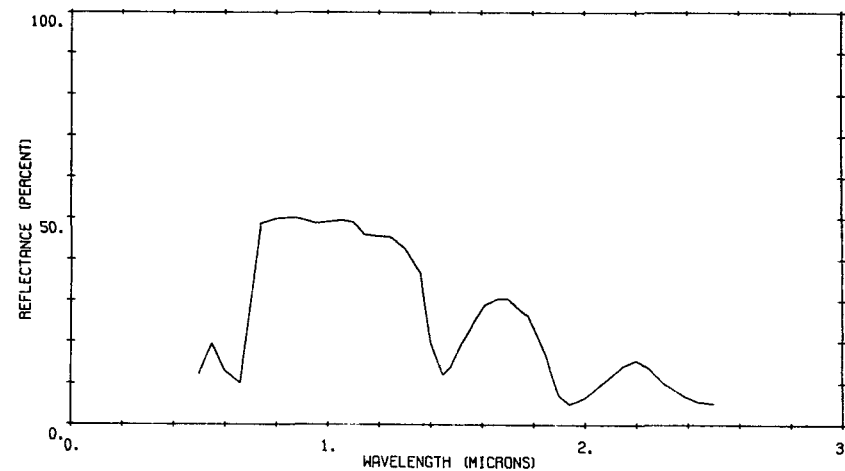
B09013 011

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN TWELFTH NODAL POSITION ON STEM AS MEASURED FROM THE PLANT  
APEX.



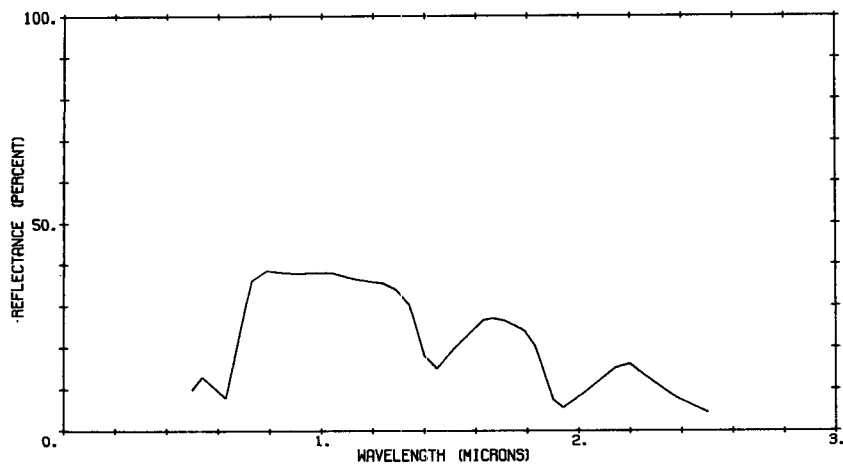
B09013 012

COTTON LEAF (GOSSYPIMUM HIRSUTUM) GROWN IN A GREENHOUSE, LEAF  
IN THIRTEENTH NODAL POSITION ON STEM AS MEASURED FROM THE  
PLANT APEX.



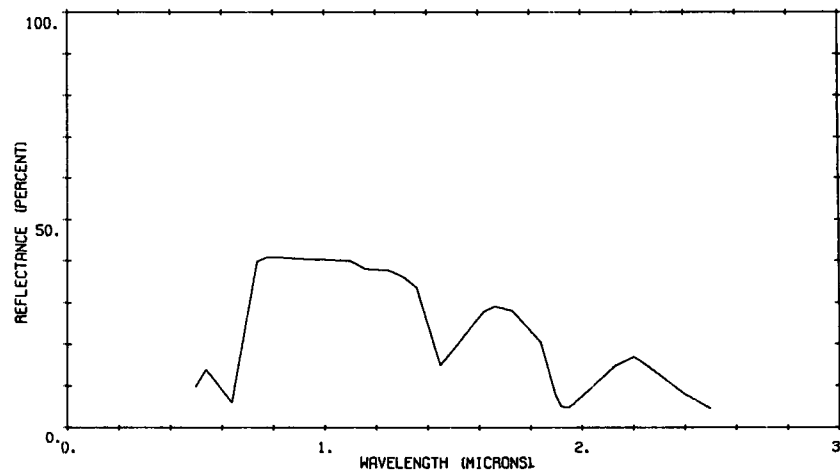
B09014 001

UPPER SURFACE OF COTTON LEAF (THIRD LEAF TO APPEAR) FROM A  
LABORATORY-GROWN PLANT, MEASURED 3.5 DAYS AFTER APPEARING.



B09014 002

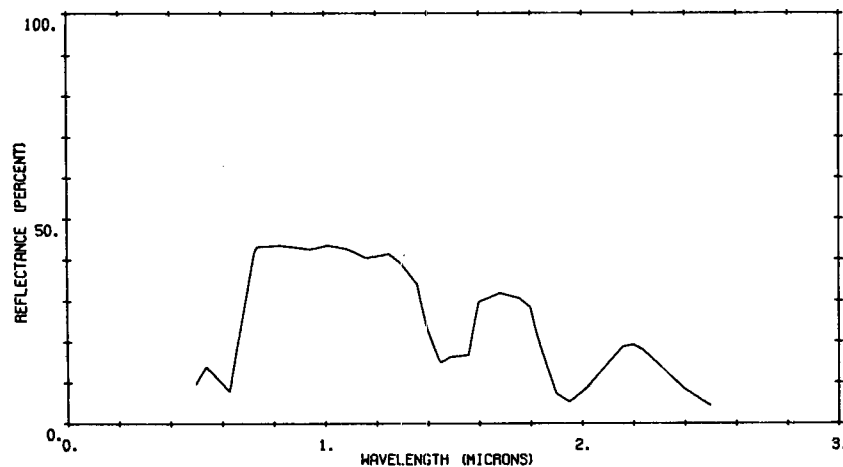
UPPER SURFACE OF COTTON LEAF (THIRD LEAF TO APPEAR) FROM A  
LABORATORY-GROWN PLANT, MEASURED 5.8 DAYS AFTER APPEARING.



BGCOA 4

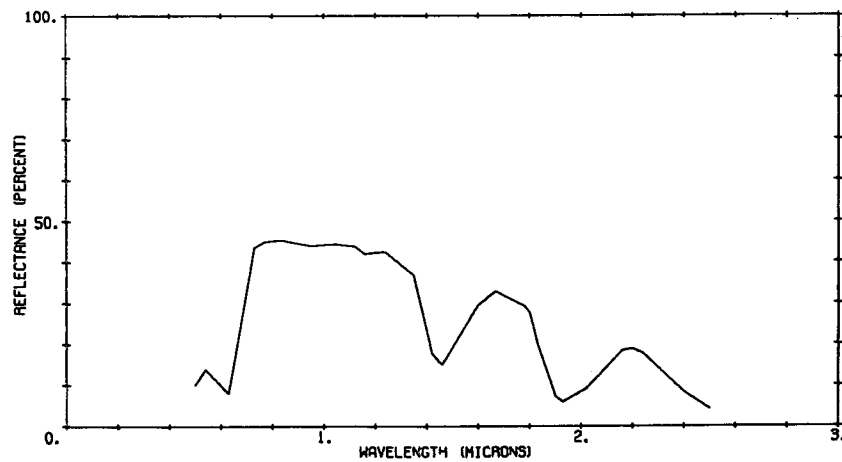
B09014 003

UPPER SURFACE OF COTTON LEAF (THIRD LEAF TO APPEAR) FROM A  
LABORATORY-GROWN PLANT, MEASURED 8.0 DAYS AFTER APPEARING.



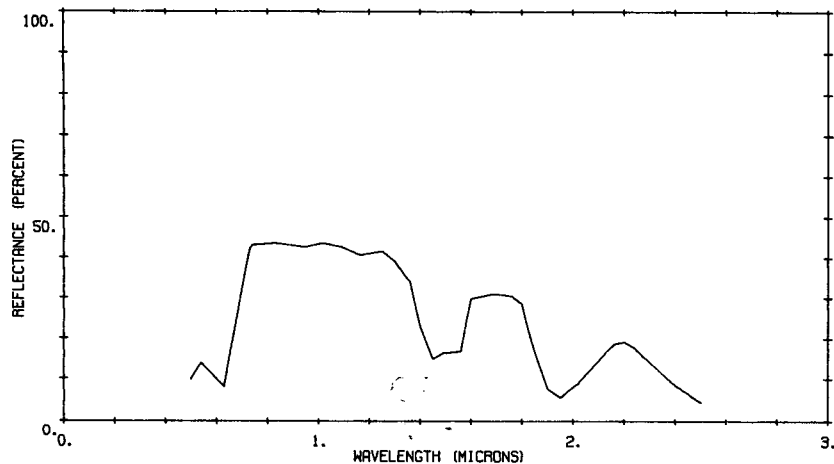
B09014 004

UPPER SURFACE OF COTTON LEAF (THIRD LEAF TO APPEAR) FROM A  
LABORATORY-GROWN PLANT, MEASURED 10.8 DAYS AFTER APPEARING.



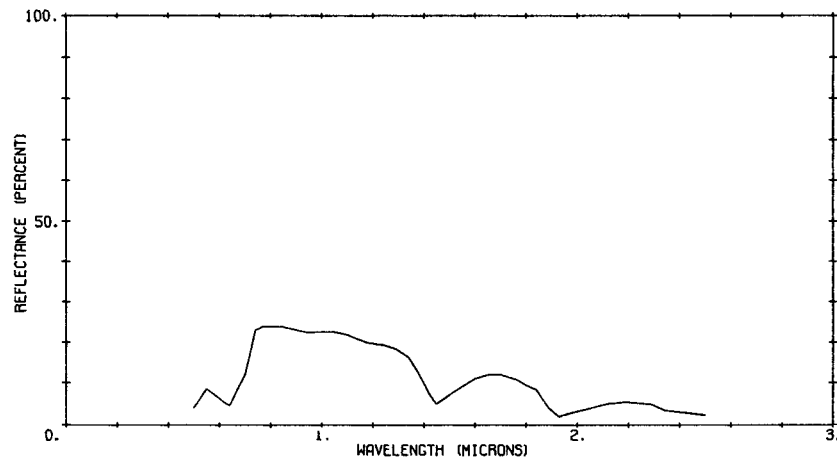
B09014 005

UPPER SURFACE OF COTTON LEAF (THIRD LEAF TO APPEAR) FROM A LABORATORY-GROWN PLANT, MEASURED 12.0 DAYS AFTER APPEARING.



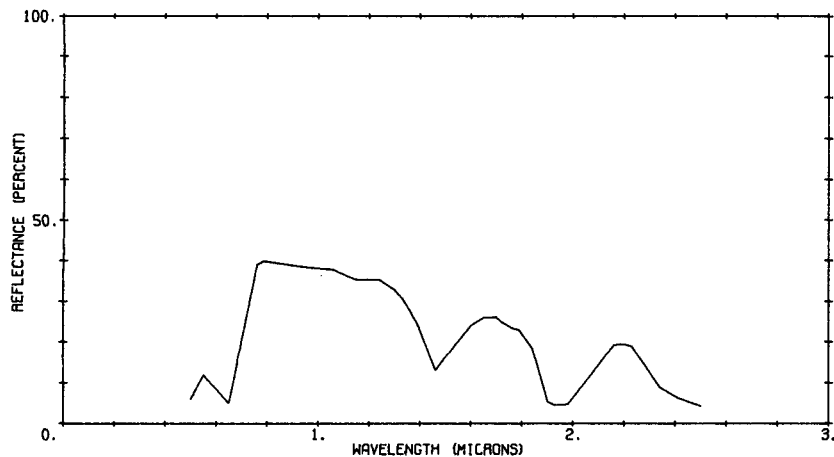
B09014 006

UPPER SURFACE OF COTTON LEAF (TWENTIETH LEAF TO APPEAR) FROM A FIELD-GROWN PLANT, MEASURED 2 DAYS AFTER APPEARING.



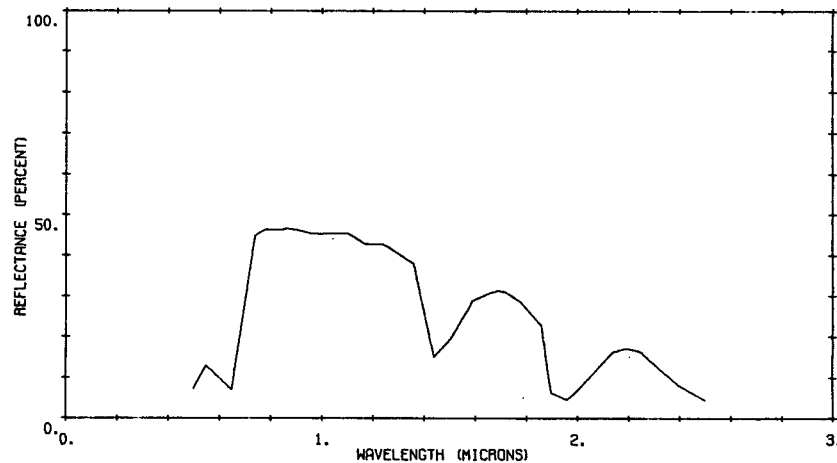
B09014 007

UPPER SURFACE OF COTTON LEAF (TWENTIETH LEAF TO APPEAR) FROM A FIELD-GROWN PLANT, MEASURED 5 DAYS AFTER APPEARING.



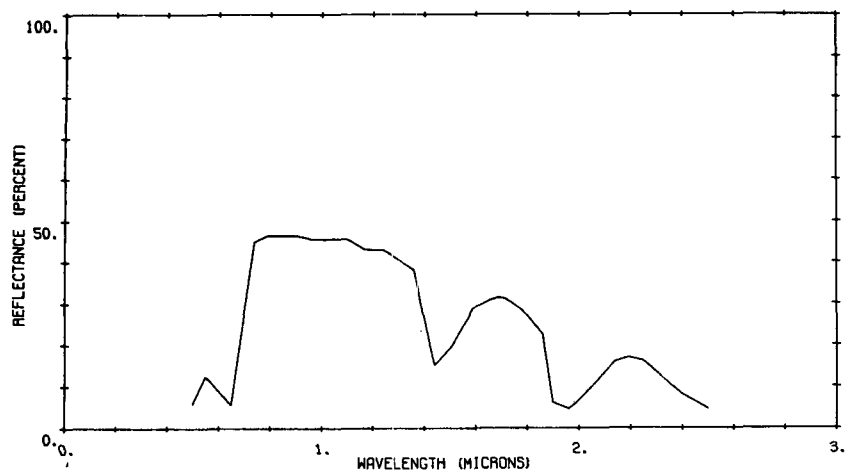
B09014 008

UPPER SURFACE OF COTTON LEAF (TWENTIETH LEAF TO APPEAR) FROM A FIELD-GROWN PLANT, MEASURED 7 DAYS AFTER APPEARING.



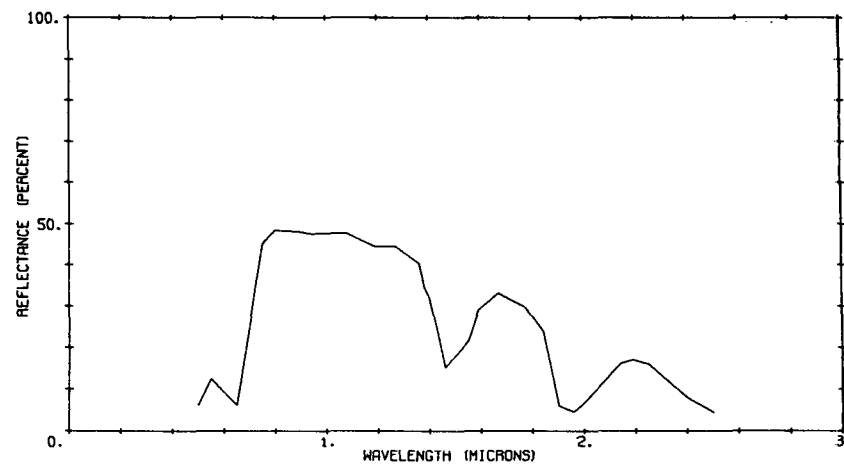
B09014 009

UPPER SURFACE OF COTTON LEAF (TWENTIETH LEAF TO APPEAR) FROM A FIELD-GROWN PLANT, MEASURED 9 DAYS AFTER APPEARING.



B09014 010

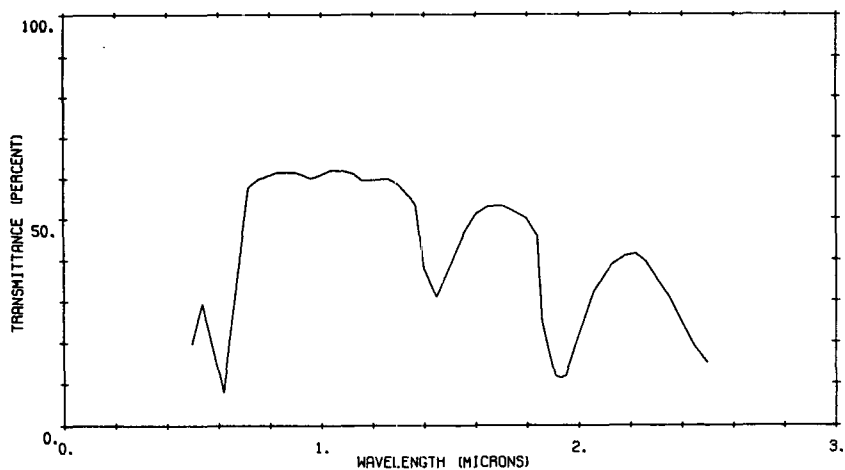
UPPER SURFACE OF COTTON LEAF (TWENTIETH LEAF TO APPEAR) FROM A FIELD-GROWN PLANT, MEASURED 12 DAYS AFTER APPEARING.



B09014 010

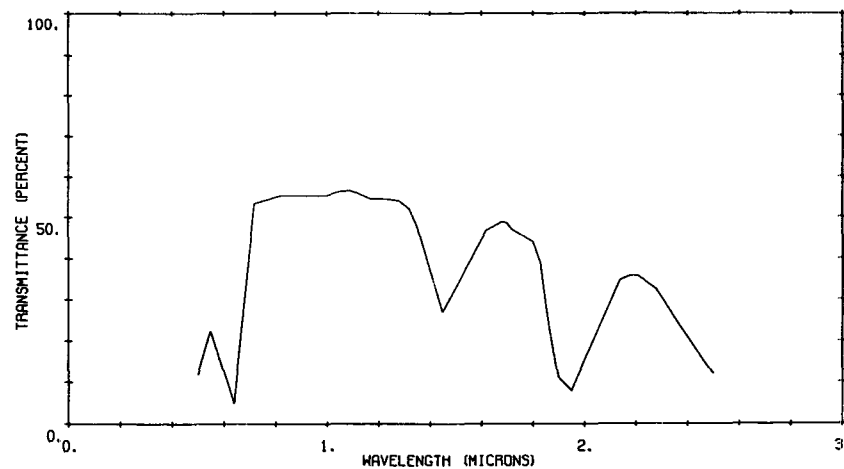
B09014 011

COTTON LEAF (THIRD LEAF TO APPEAR) FROM A LABORATORY-GROWN PLANT, MEASURED 3.5 DAYS AFTER APPEARING.



B09014 012

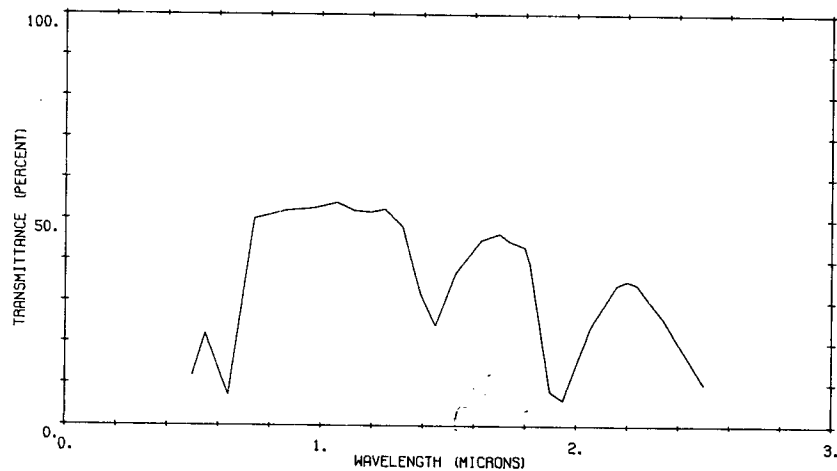
COTTON LEAF (THIRD LEAF TO APPEAR) FROM A LABORATORY-GROWN PLANT, MEASURED 5.8 DAYS AFTER APPEARING.





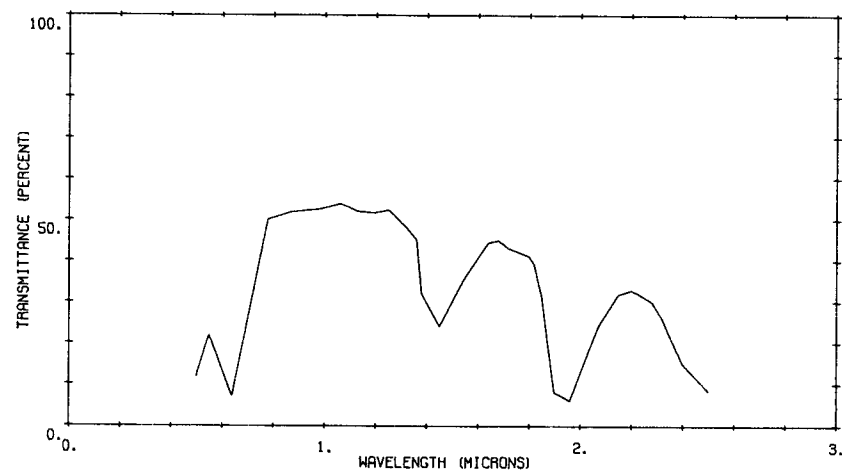
B09014 013

COTTON LEAF (THIRD LEAF TO APPEAR) FROM A LABORATORY-GROWN PLANT, MEASURED 8.0 DAYS AFTER APPEARING.



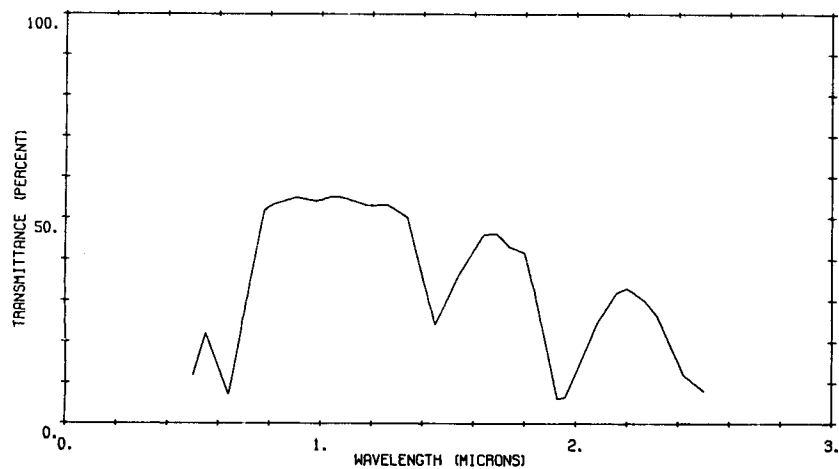
B09014 014

COTTON LEAF (THIRD LEAF TO APPEAR) FROM A LABORATORY-GROWN PLANT, MEASURED 10.8 DAYS AFTER APPEARING.



B09014 015

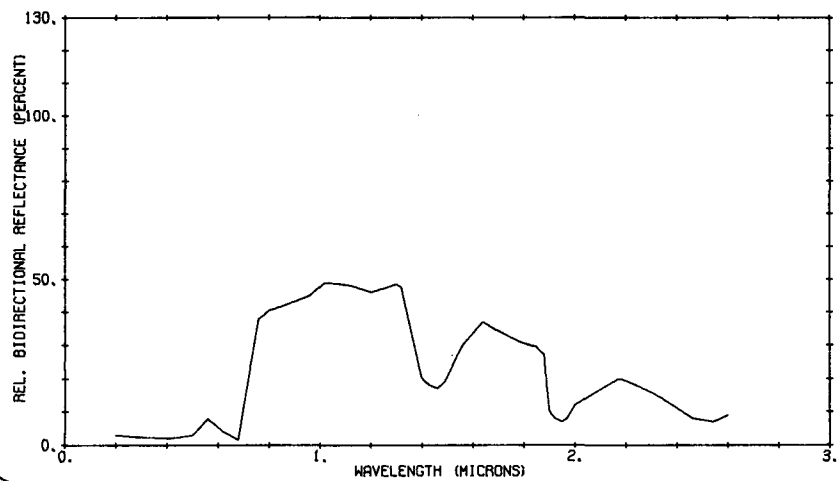
COTTON LEAF (THIRD LEAF TO APPEAR) FROM A LABORATORY-GROWN PLANT, MEASURED 12.0 DAYS AFTER APPEARING



BGCRB  
CLOVER

B09004 008

CLOVER.

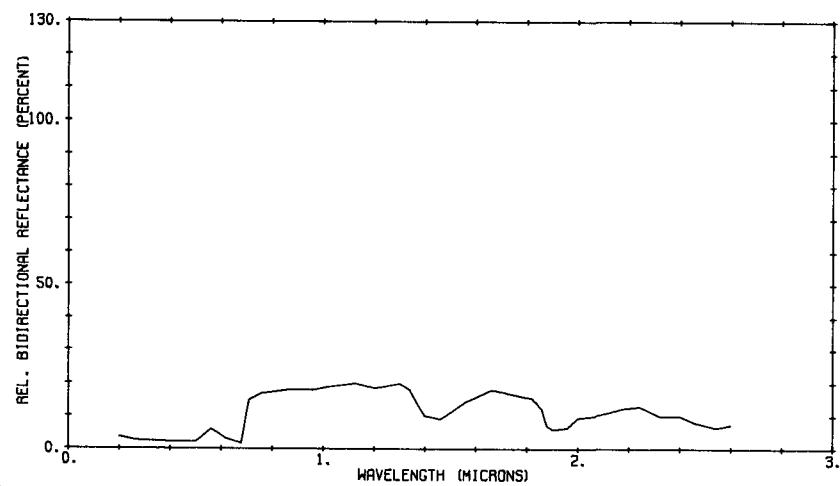


68

BGDX  
PINE FAMILY

B09004 009

PINE NEEDLES.



70

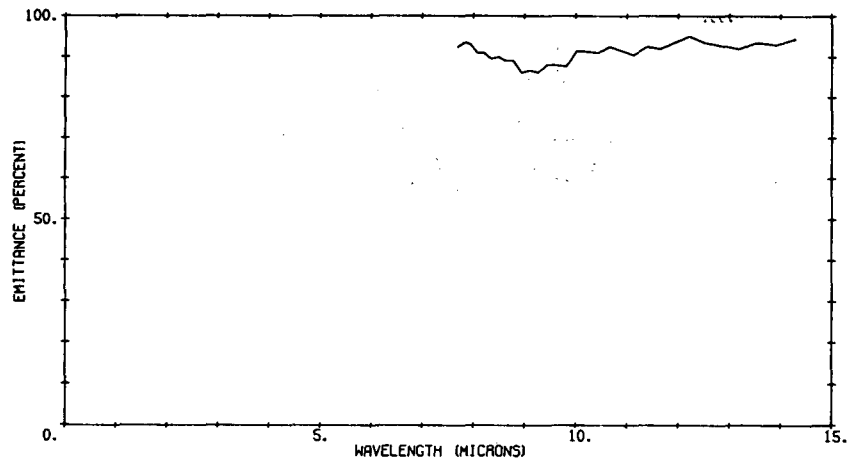
101

ACIDIC SILICATE ROCKS

(Generally Greater Than 65%  $\text{SiO}_2$ )

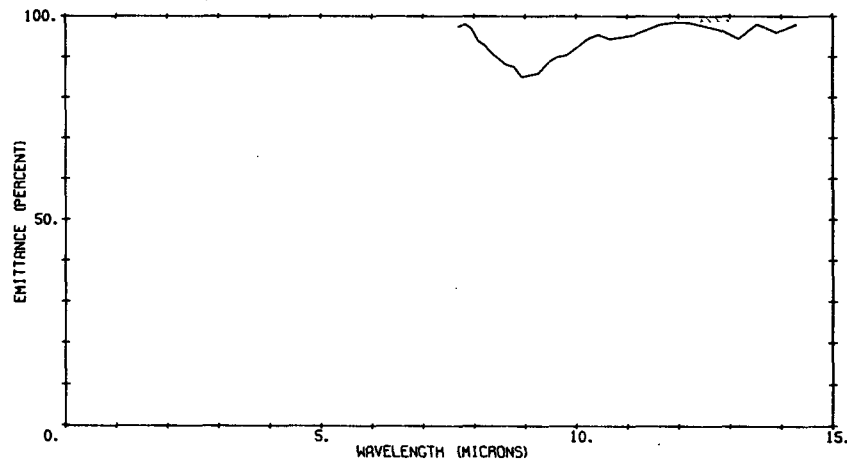
B09001 001

RHYOLITE PUMICE—DARK, FROTHY, GLASS. LOW DENSITY, LARGE BUBBLES, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



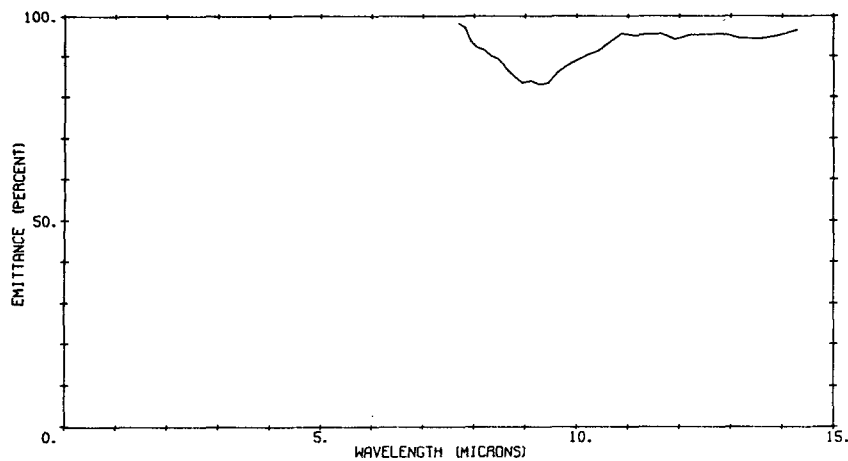
B09001 002

RHYOLITE PUMICE—DARK, FROTHY, GLASS. LOW DENSITY, LARGE BUBBLES, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



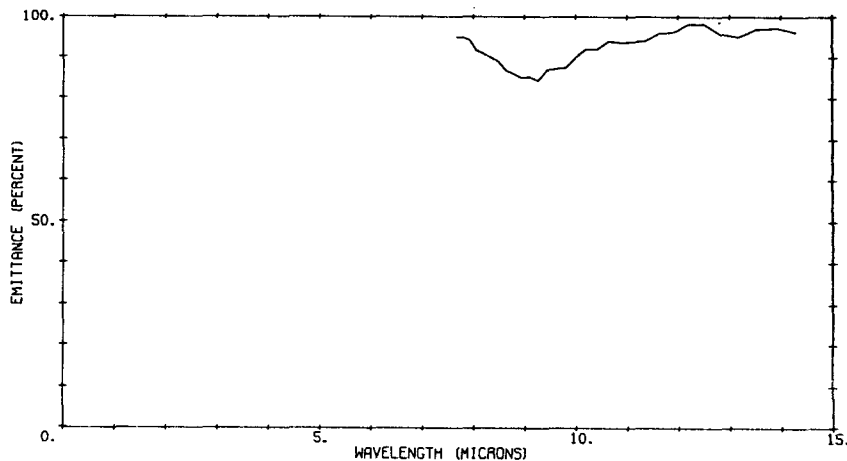
72  
B09001 003

PUMICEOUS RHYOLITE—GRAY, BLOCKY, FINE-FROTHY GLASS. NATURAL BUFF, WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



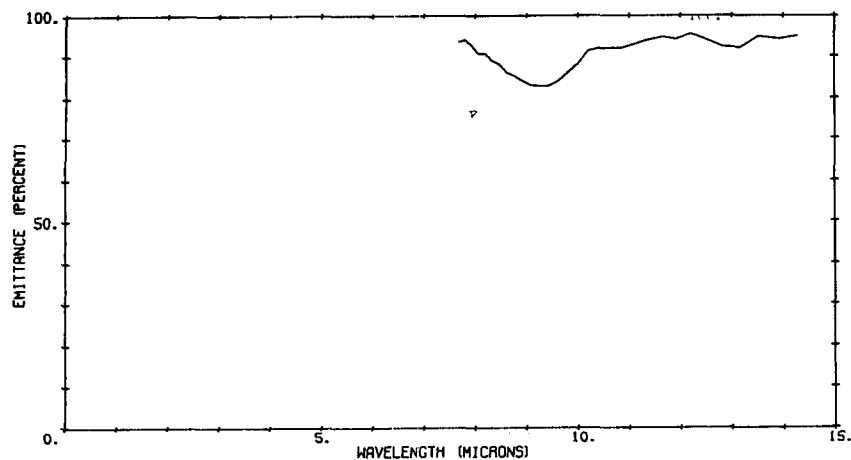
B09001 004

PUMICEOUS RHYOLITE—GRAY, BLOCKY, FINE-FROTHY GLASS, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



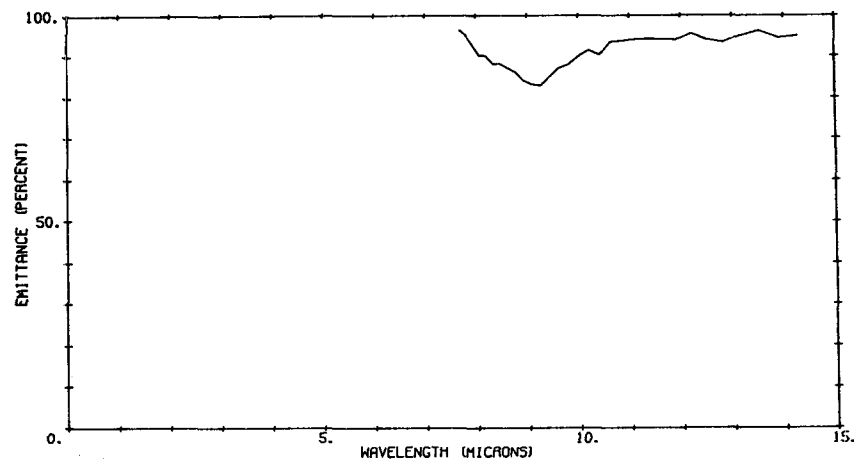
B09001 005

PUMICEOUS RHYOLITE—GRAY, FROTHY, GLASS WITH MEDIUM-SIZED PORES, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



B09001 006

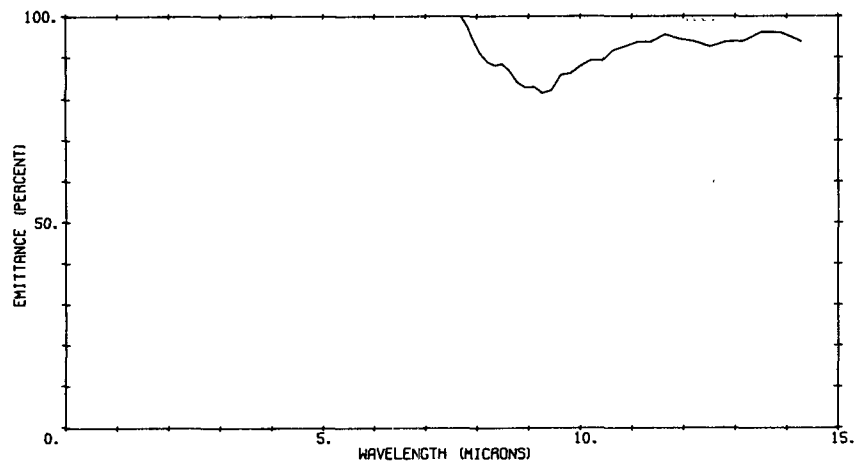
PUMICEOUS RHYOLITE—GRAY, FROTHY, GLASS WITH MEDIUM-SIZED PORES, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



73

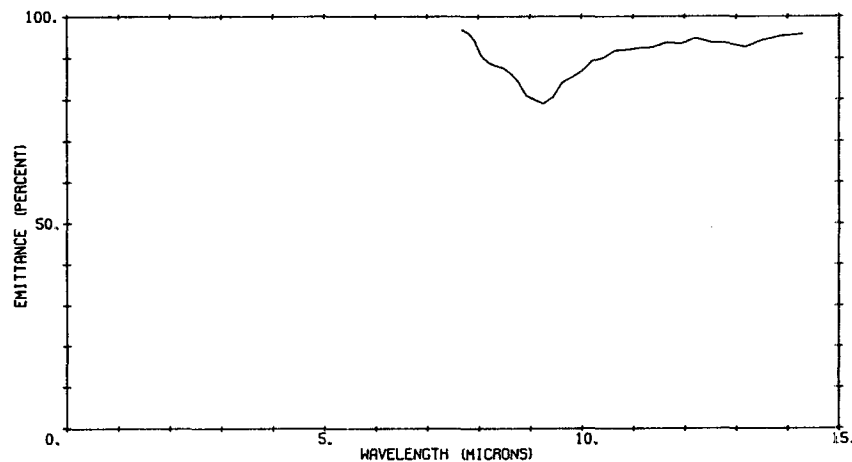
B09001 007

PUMICEOUS RHYOLITE—GRAY, FIBROUS-TEXTURED GLASS, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



B09001 008

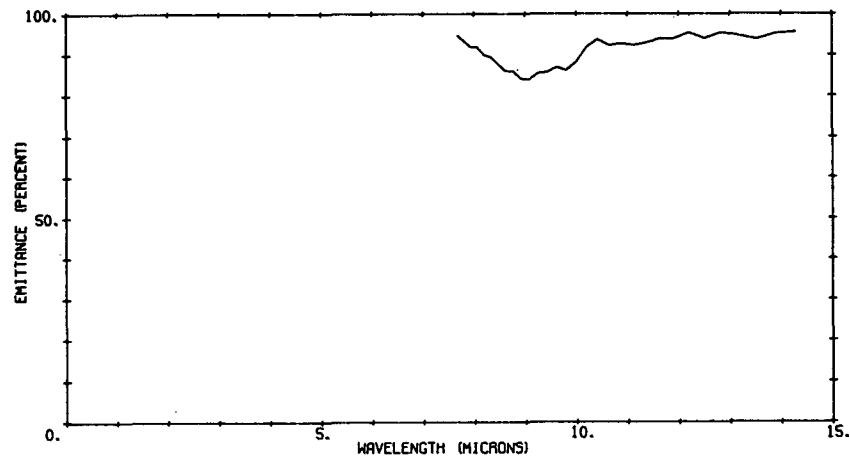
PUMICEOUS RHYOLITE—GRAY, FIBROUS-TEXTURED GLASS, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).





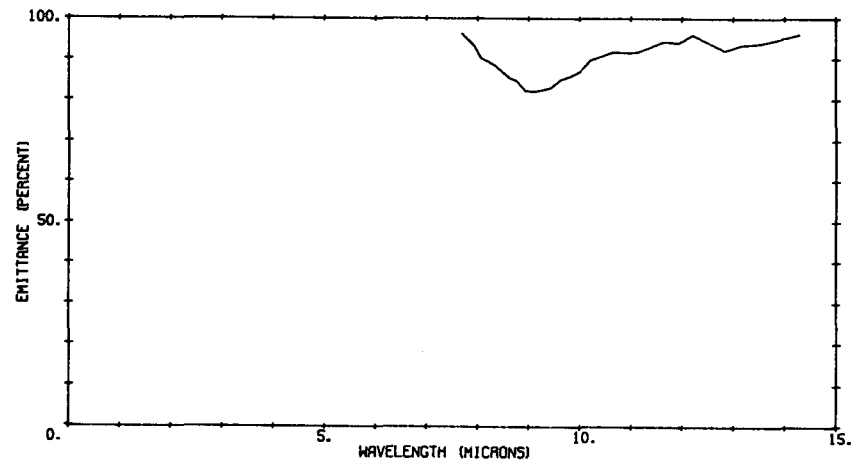
809001 009

PORPHYRITIC RHYOLITE—FELDSPAR PHENOCRYSTS SET IN VESICULAR GLASS, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



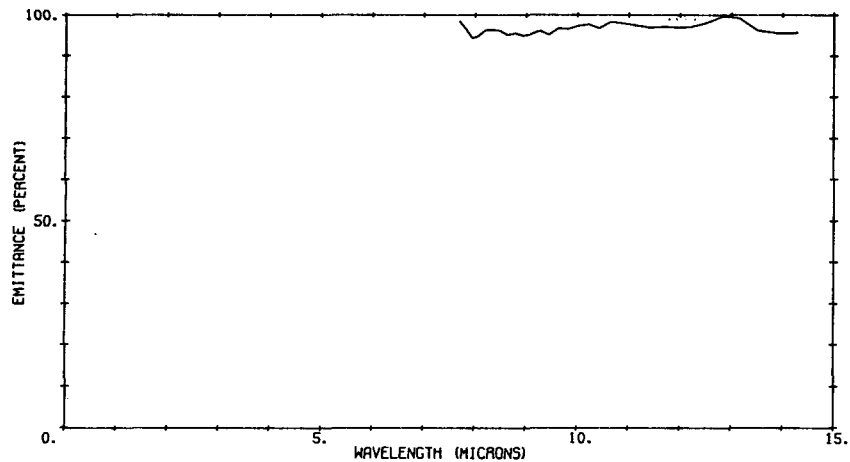
809001 010

PORPHYRITIC RHYOLITE—FELDSPAR PHENOCRYSTS SET IN VESICULAR GLASS, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



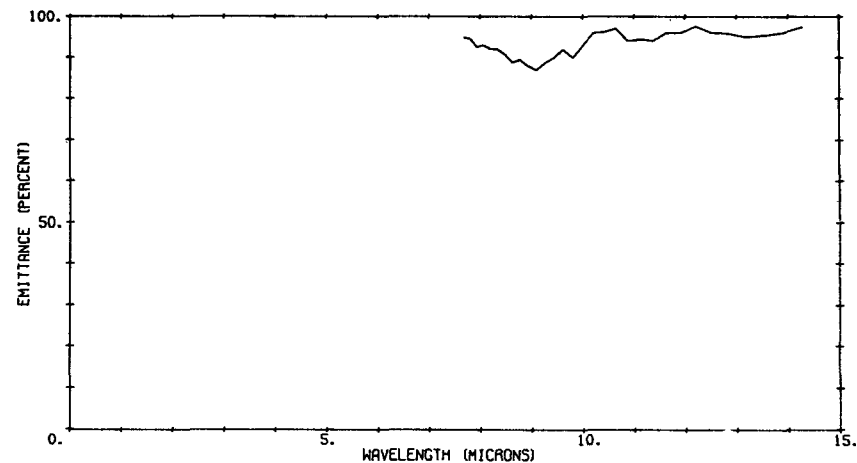
809001 011

CEMENTED RHYOLITE SAND—RHYOLITE BEACH SAND LIGHTLY CEMENTED WITH CALCAREOUS LAKE SALTS, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



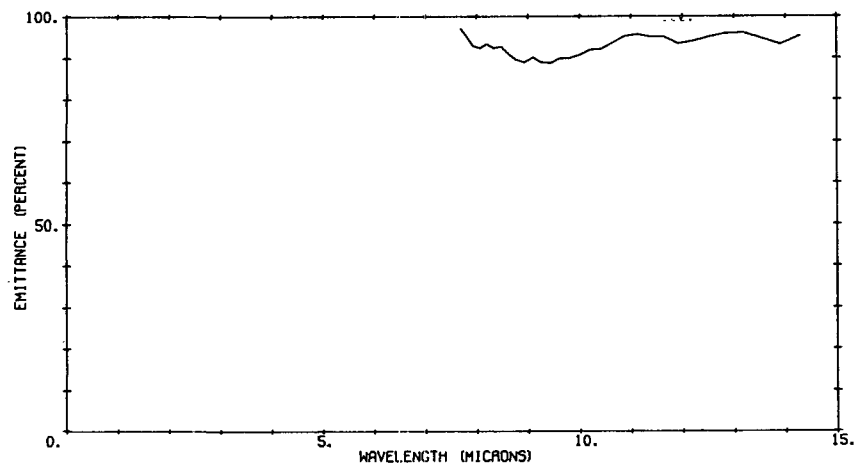
809001 012

RHYOLITE SAND—UNCONSOLIDATED, WELL-SORTED, RHYOLITIC BEACH SAND—MOSTLY GRAINS OF OBSIDIAN WITH SOME PUMICE, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



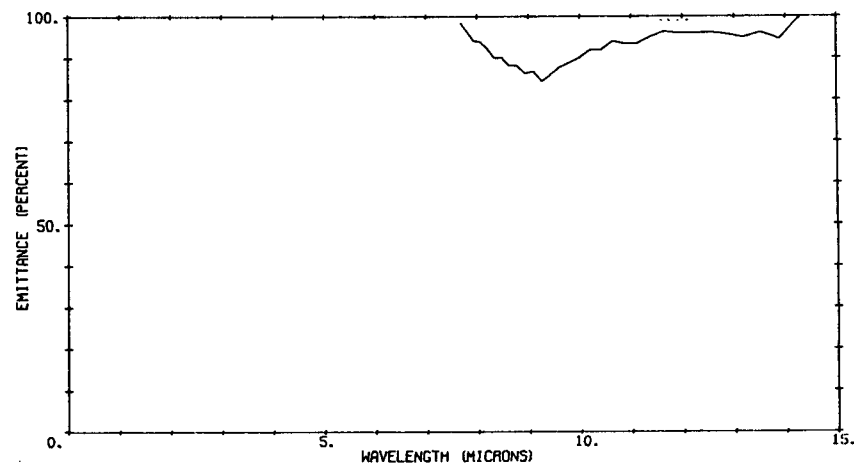
B09001 013

BISHOP TUFF—TAN, LOW DENSITY, CRYSTALLITHIC TUFF, UPPERMOST UNIT, NATURAL WEATHERED SURFACE, (MONO CRATERS REGIONS, CALIFORNIA).



B09001 014

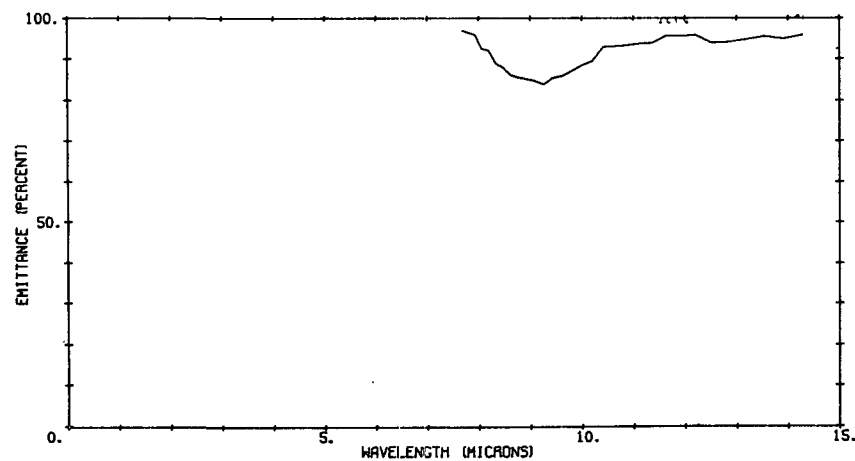
BISHOP TUFF—TAN, LOW DENSITY, CRYSTALLITHIC TUFF, UPPERMOST UNIT, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



75

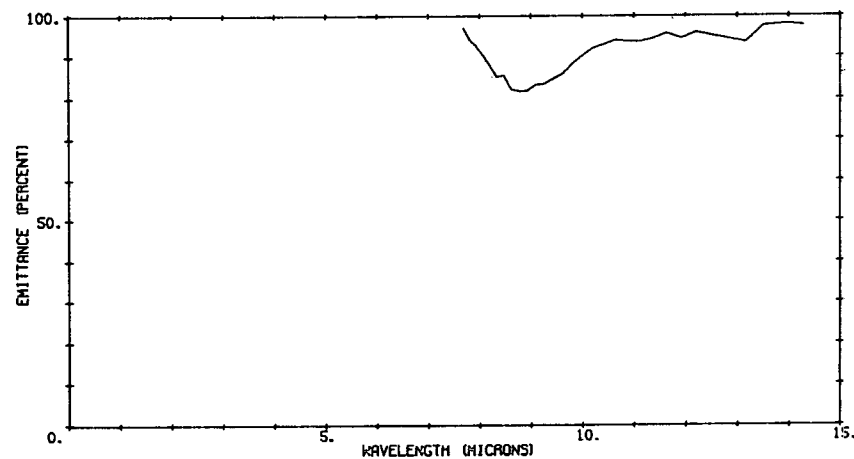
B09001 015

BISHOP TUFF—GRAY-TAN, DENSE, CRYSTALLITHIC TUFF, MIDDLE-WELDED UNIT, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION CALIFORNIA).



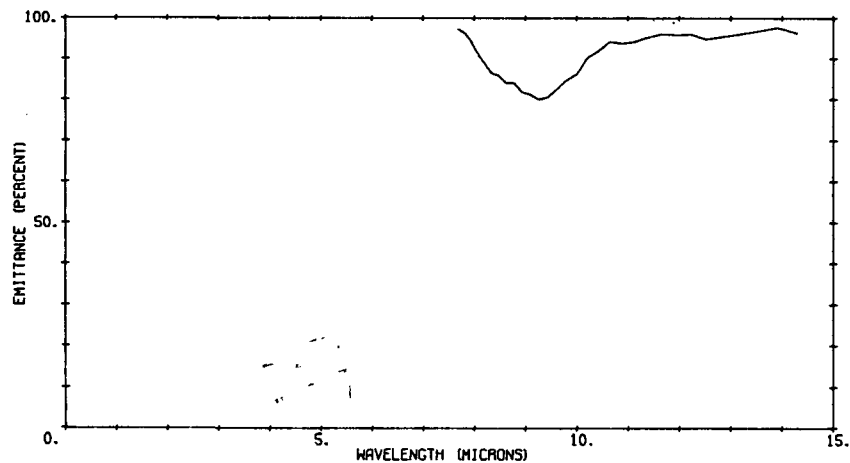
B09001 016

BISHOP TUFF—GRAY-TAN, DENSE, CRYSTALLITHIC TUFF, MIDDLE-WELDED UNIT, SAWED SURFACE, (MONO CRATERS REGION CALIFORNIA).



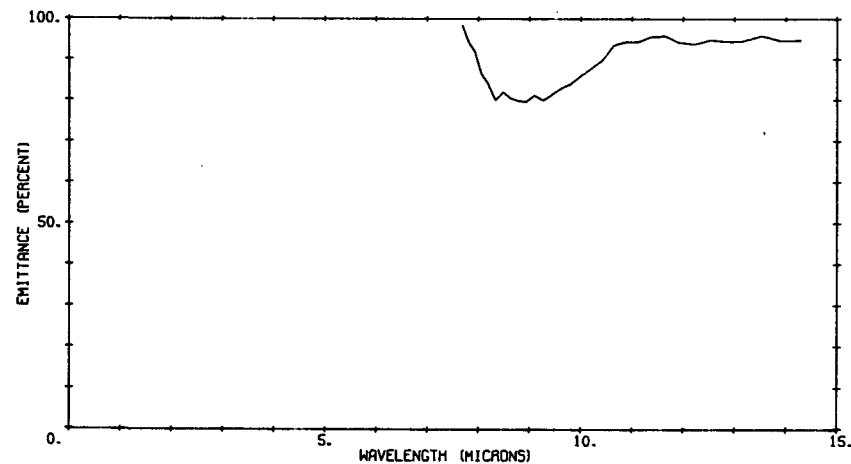
B09001 017

QUARTZ MONZONITE—BIOTITE BEARING, MEDIUM-GRAINED, NATURAL WEATHERED SURFACE, (MONO CRATERS REGIONS, CALIFORNIA).



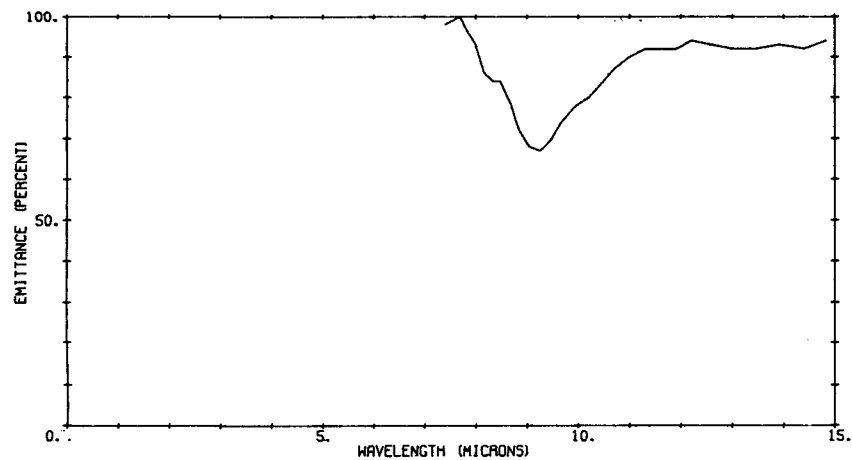
B09001 018

QUARTZ MONZONITE—BIOTITE BEARING, MEDIUM-GRAINED, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



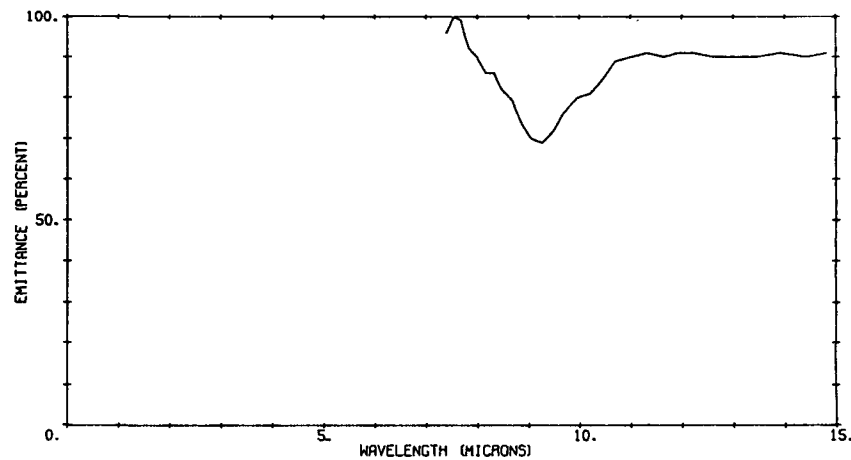
B09002 001

OBSIDIAN, (MONO CRATERS REGION, CALIFORNIA).

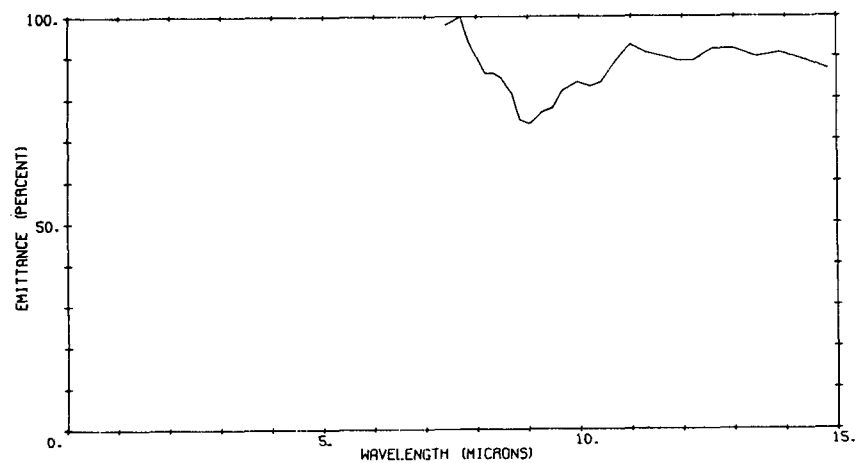


B09002 002

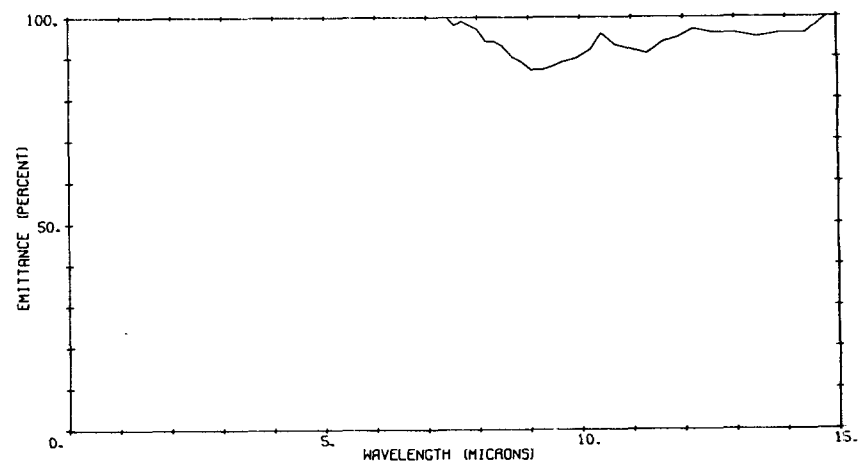
OBSIDIAN, BROKEN SURFACE, (MONO CRATERS REGION, CALIFORNIA).



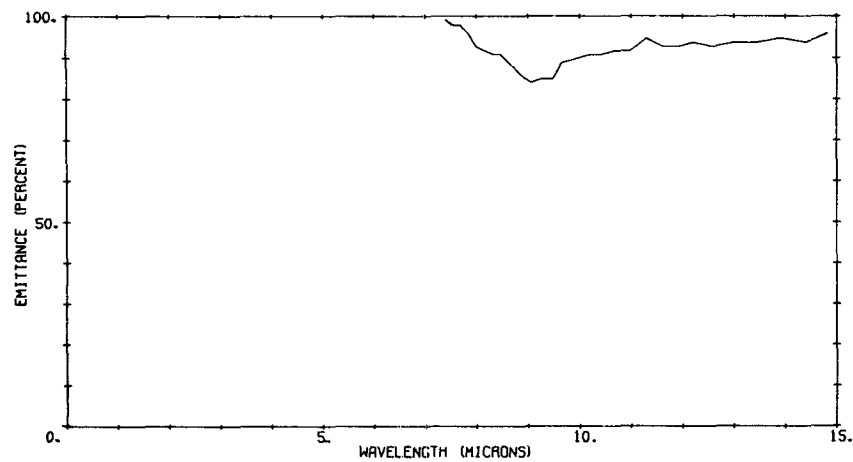
B09002 003  
 RHYOLITE PUMICE, (MONO CRATERS REGION, CALIFORNIA).



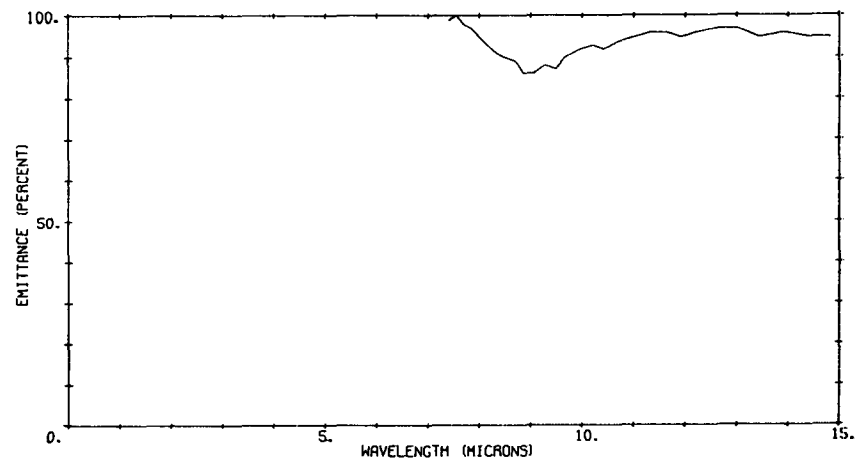
B09002 004  
 RHYOLITE PUMICE, (MONO CRATERS REGIONS, CALIFORNIA).



66  
 B09002 005  
 BISHOP TUFF, WEATHERED, UPPER UNIT, (MONO CRATERS REGION, CALIFORNIA).

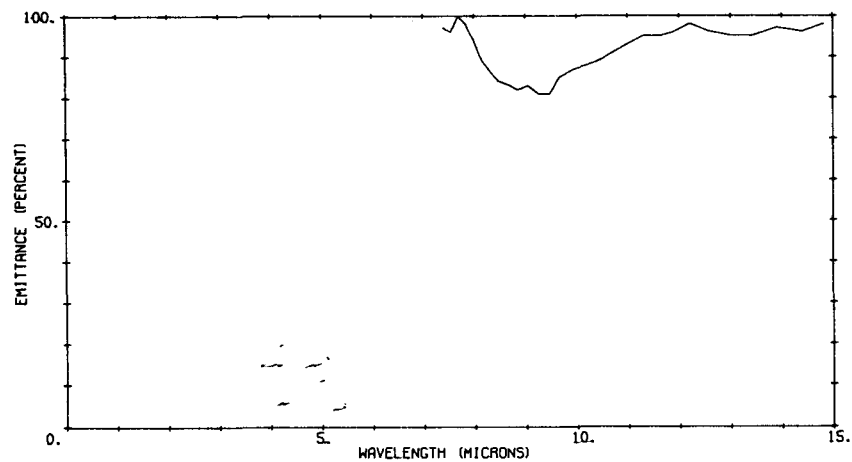


B09002 006  
 BISHOP TUFF, WEATHERED, WELDED MIDDLE UNIT, (MONO CRATERS REGION, CALIFORNIA).



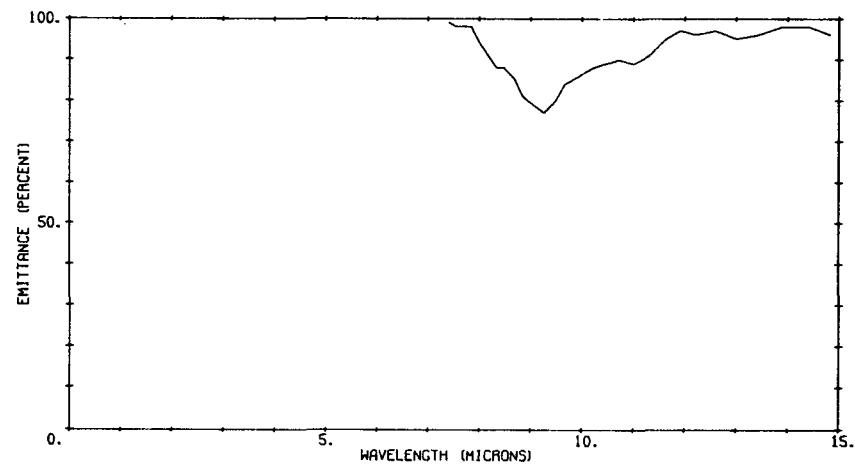
B09002 007

QUARTZ MONZONITE, WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



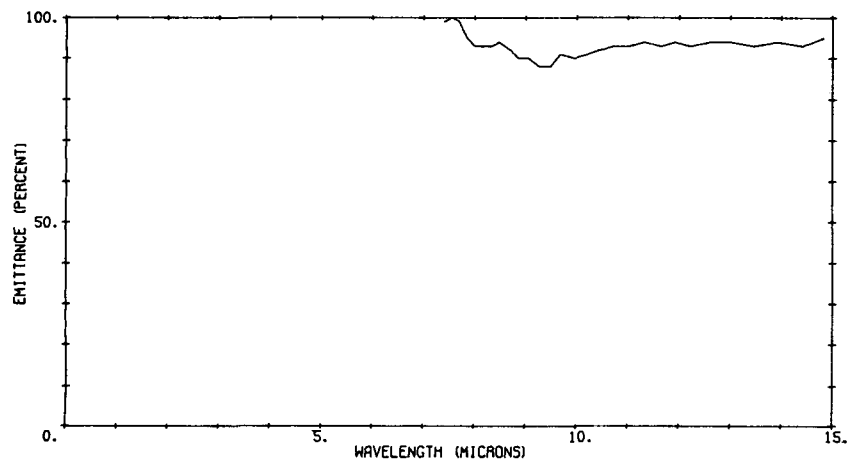
B09002 008

RHYOLITE PUMICE, SAWED SURFACE, (MONO CRATERS REGION IN CALIFORNIA).



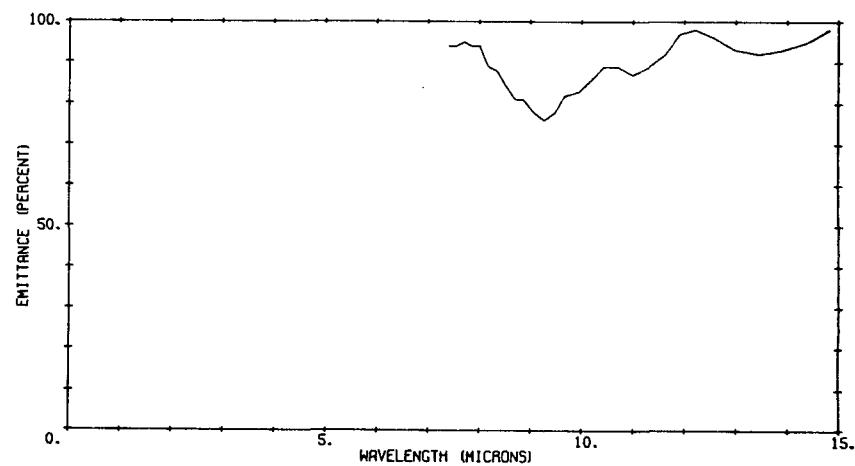
B09002 009

OLDER RHYOLITE, WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



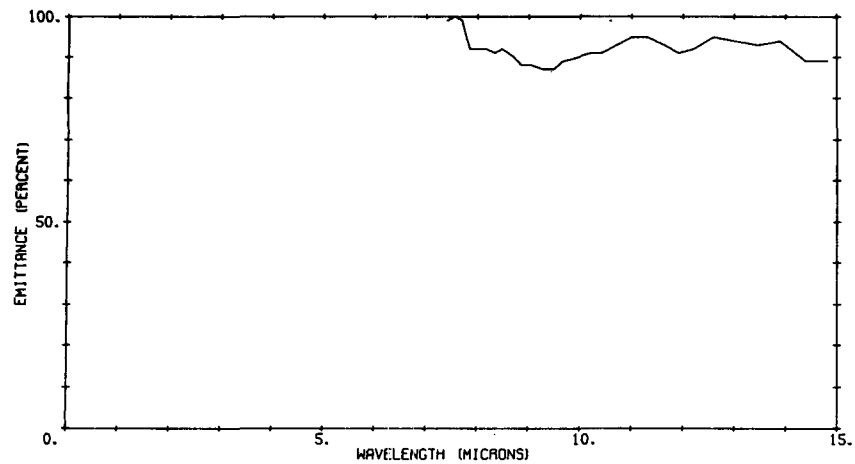
B09002 010

OLDER RHYOLITE, SAWED SURFACE, (MONO CRATERS REGION, CALIF.)



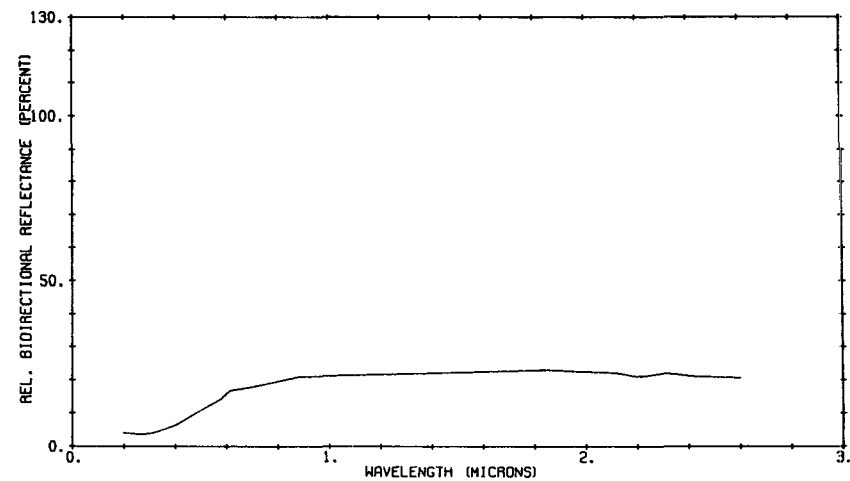
B09002 011

RHYOLITIC BEACH SAND, (MONO CRATERS REGION, CALIFORNIA).



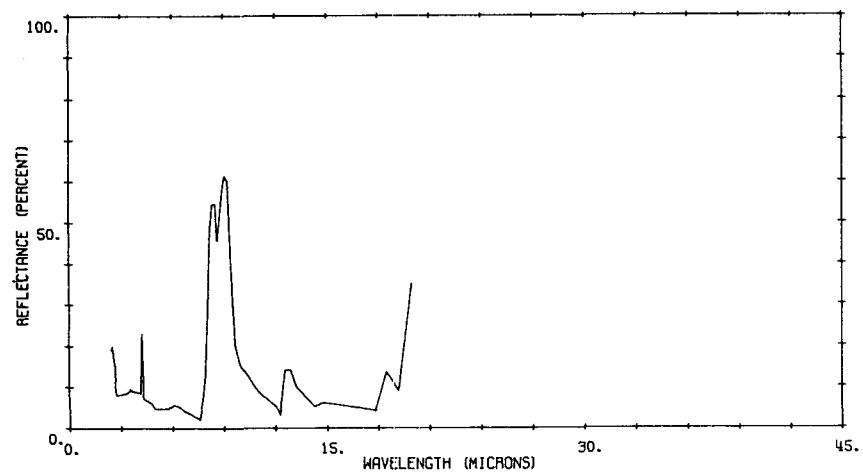
B09004 011

PUMICE.



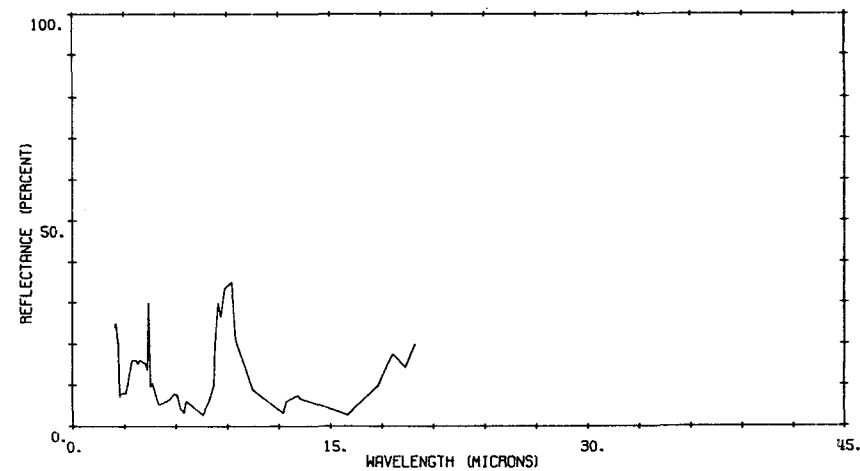
66  
B09006 006

PEGMATITE (REAL DE CURUCUPATSEO, MICHOACAN, MEXICO).



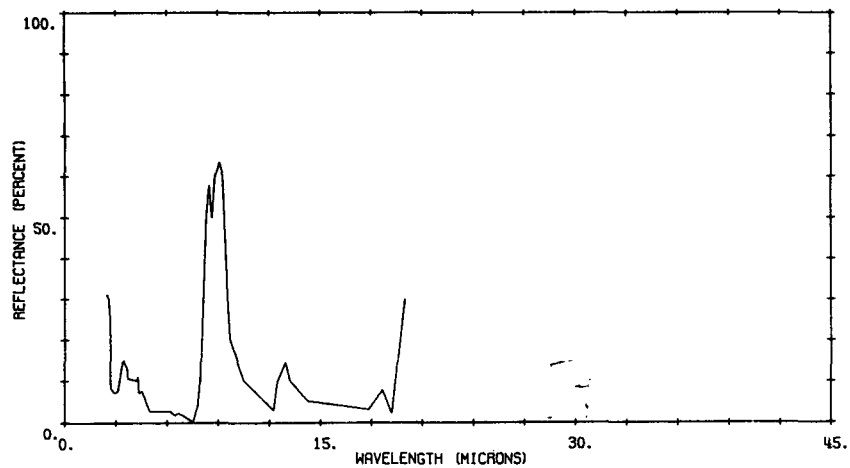
B09006 007

PEGMATITE (REAL DE CURUCUPATSEO, MICHOACAN, MEXICO).



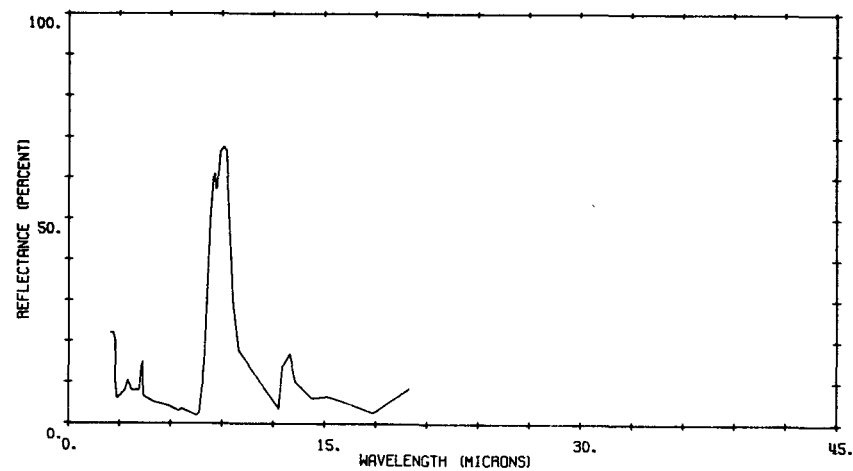
B09006 008

PEGMATITE (REAL DE CURUCUPATSEO, MICHOACAN, MEXICO).



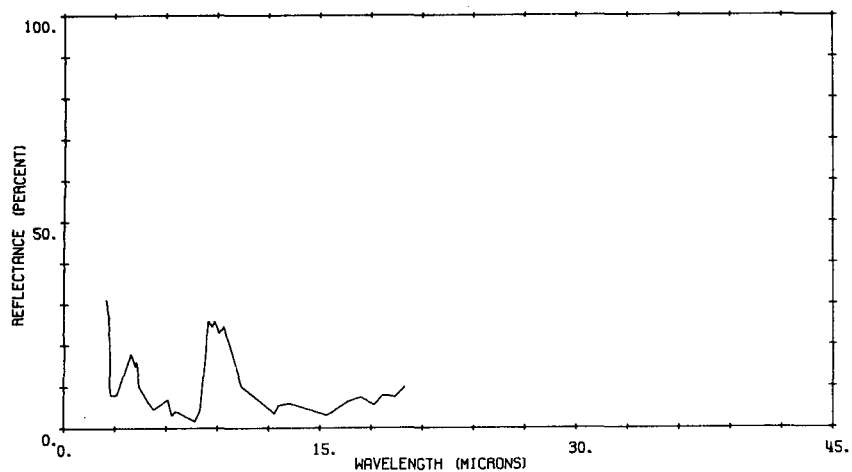
B09006 009

PEGMATITE (REAL DE CURUCUPATSEO, MICHOACAN, MEXICO).



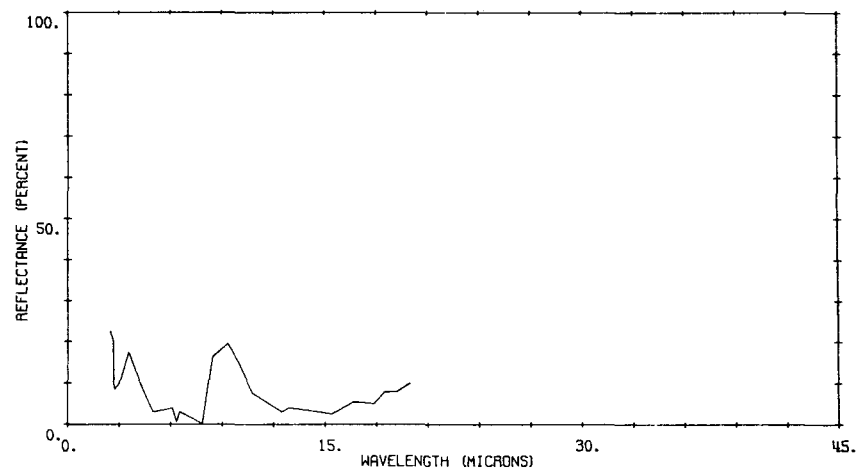
B09006 012

GRANITE GNEISS (CUZIJIMICUILPA, GRO., MEXICO).



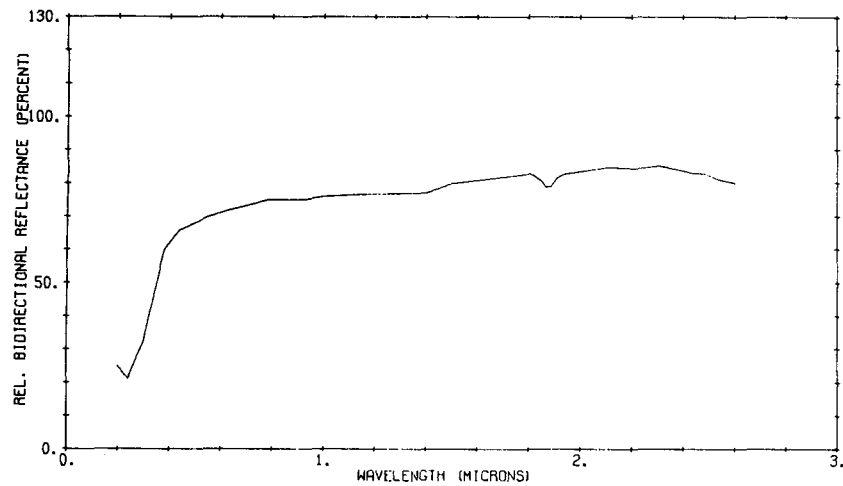
B09006 013

GNEISS WITH QUARTZ AND FELDSPAR (PUERTO ESCONDIDO, OAXACA, MEXICO).



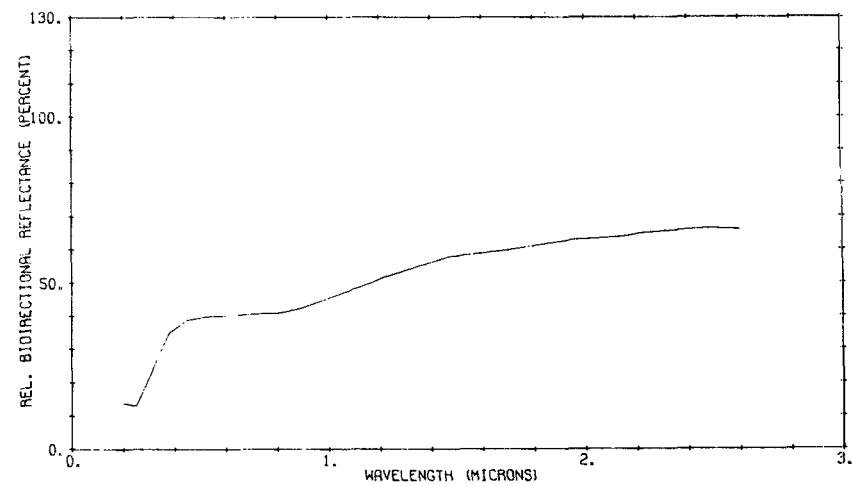
B09012 004

GREY RHYOLITE (COLORADO), PARTICLE DIAM.—0 TO 37 MICRONS.



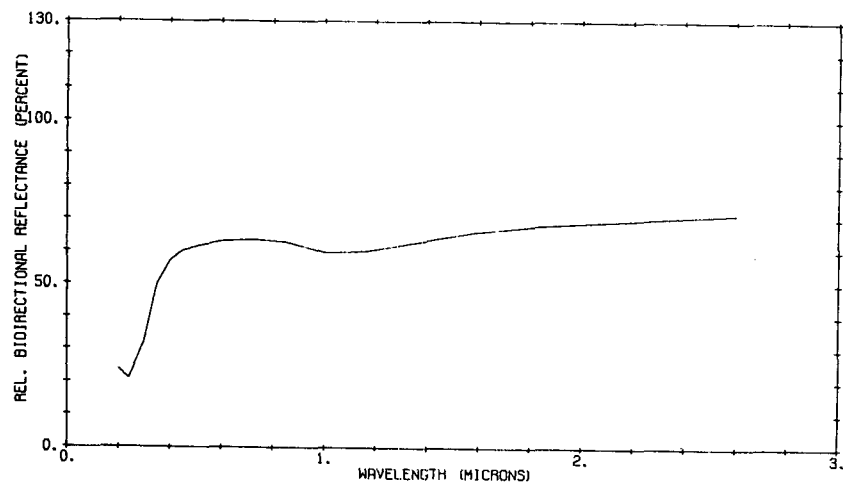
B09012 005

HORNBLende GRANITE (MASS.), PARTICLE DIAM.—0 TO 37 MICRONS.



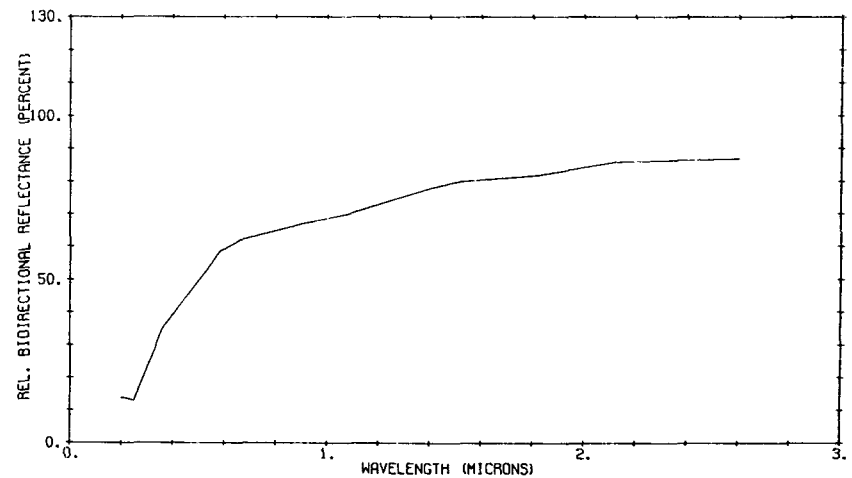
B09012 007

OBSIDIAN (OREGON), PARTICLE DIAM.—0 TO 37 MICRONS.



B09012 010

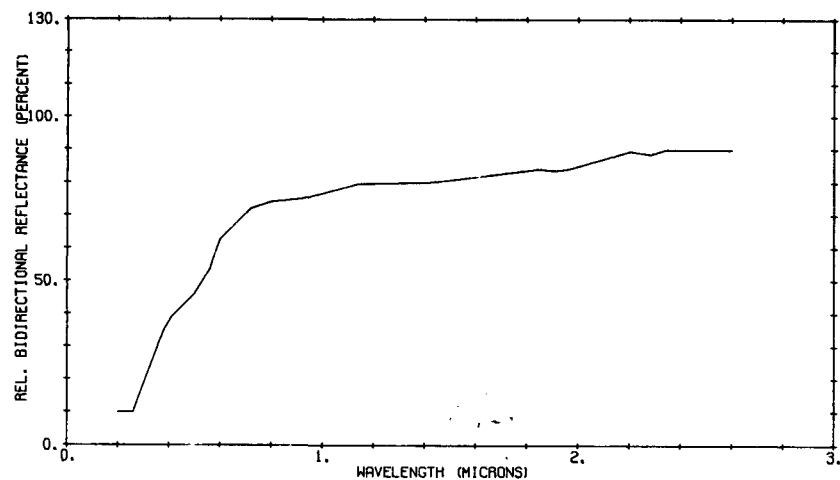
PORPHYRY FELSITE (MASS.), PARTICLE DIAM.—0 TO 37 MICRONS.





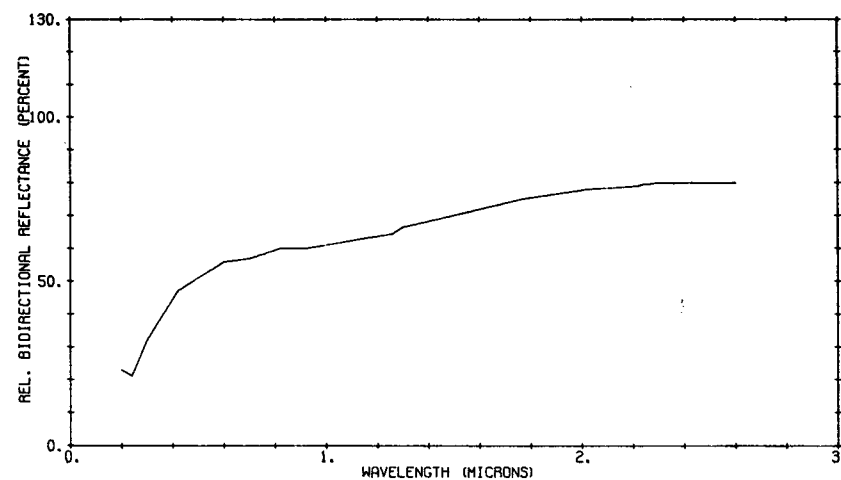
B09012 012

PINK RHYOLITE (COL.), PARTICLE DIAM.—0 TO 37 MICRONS.



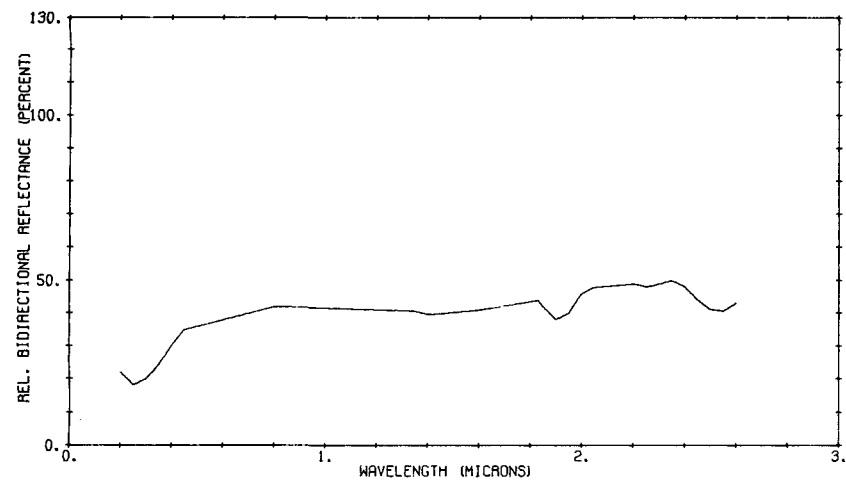
B09012 014

BIOTITE GRANITE (R.I.), PARTICLE DIAM.—0 TO 37 MICRONS.



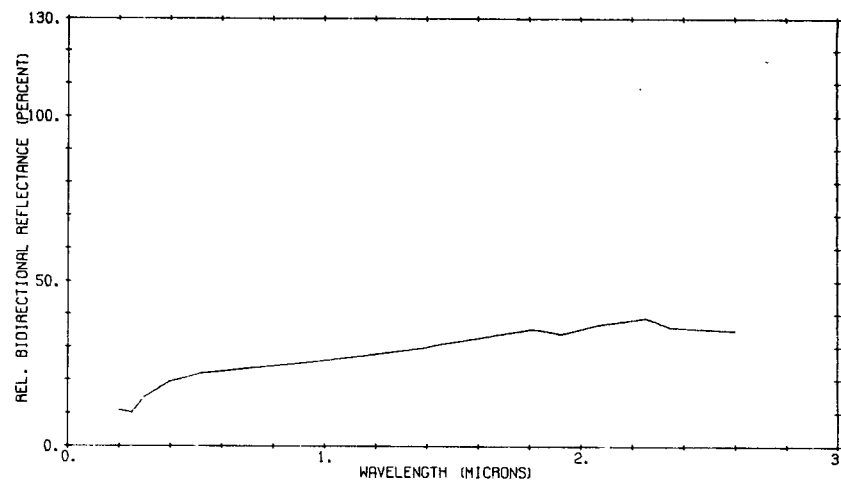
B09012 019

GREY RHYOLITE (COL.), PARTICLE DIAM.—420 TO 500 MICRONS.



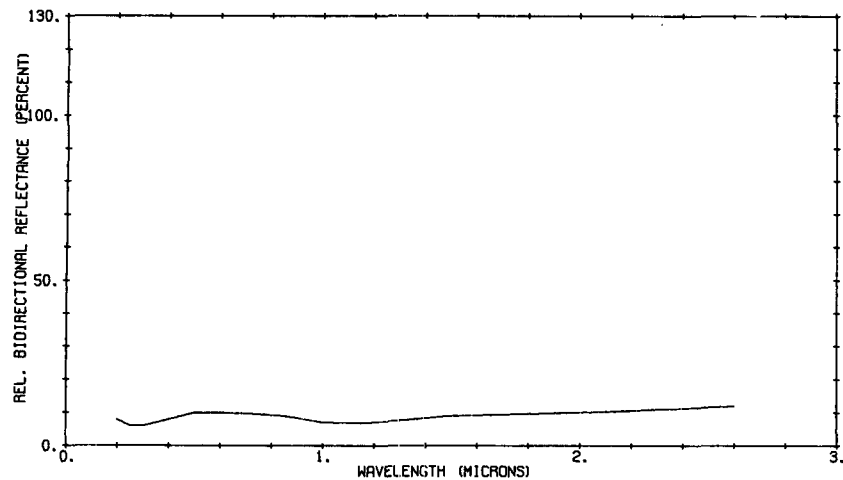
B09012 020

HORNBLende GRANITE (MASS.), PARTICLE DIAM.—420 TO 500 MICRONS.



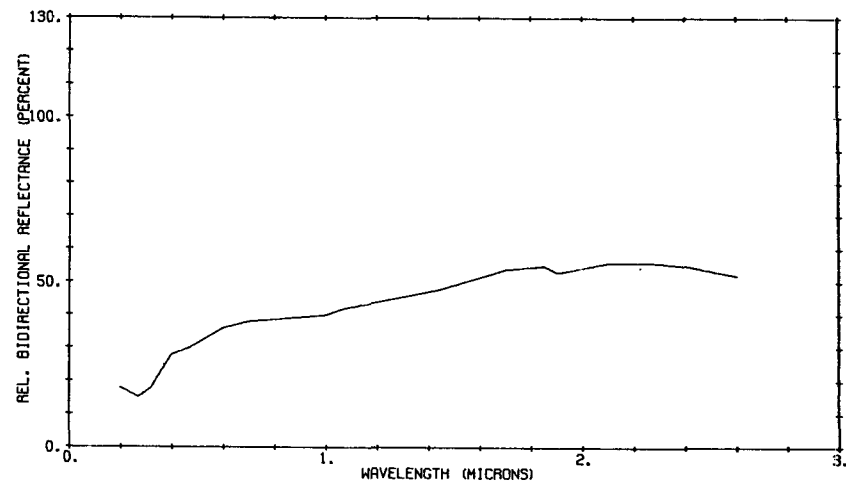
B09012 022

OBSIDIAN (OREGON), PARTICLE DIAM.— 420 TO 500 MICRONS.



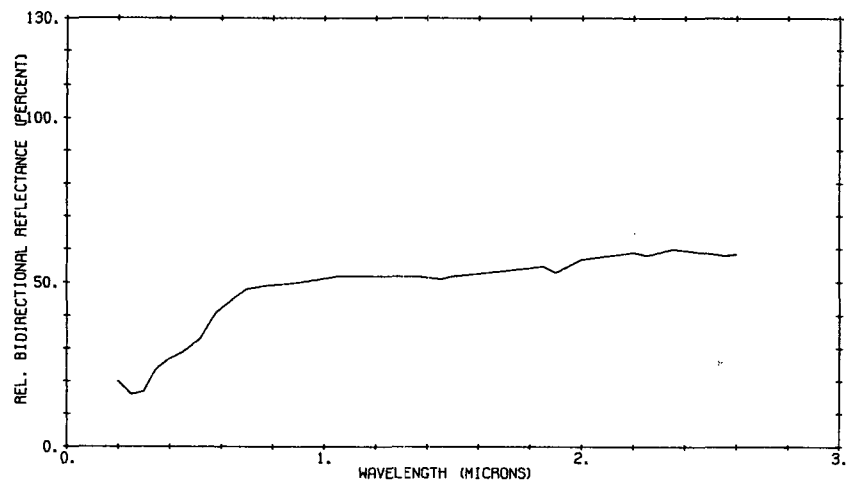
B09012 025

PORPHYRY FELSITE (MASS.), PARTICLE DIAM.—420 TO 500 MICRONS.



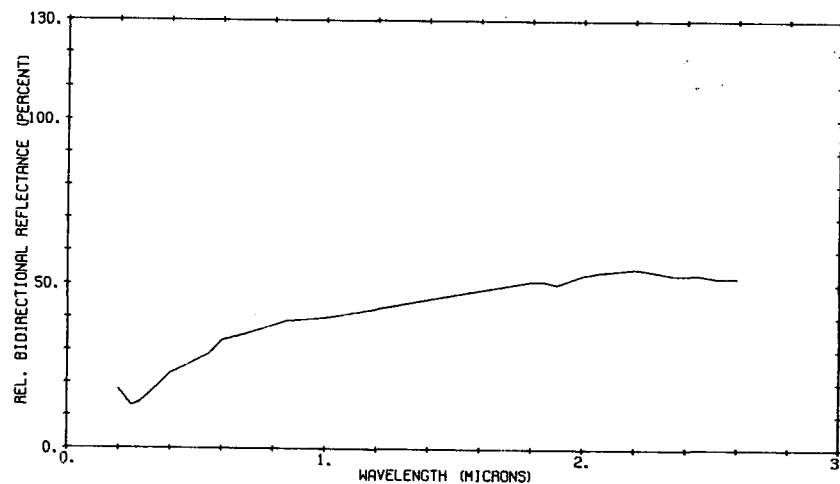
83 B09012 027

PINK RHYOLITE (COL.), PARTICLE DIAM.— 420 TO 500 MICRONS.



B09012 029

BIOTITE GRANITE (R.I.), PARTICLE DIAM.— 420 TO 500 MICRONS.



102

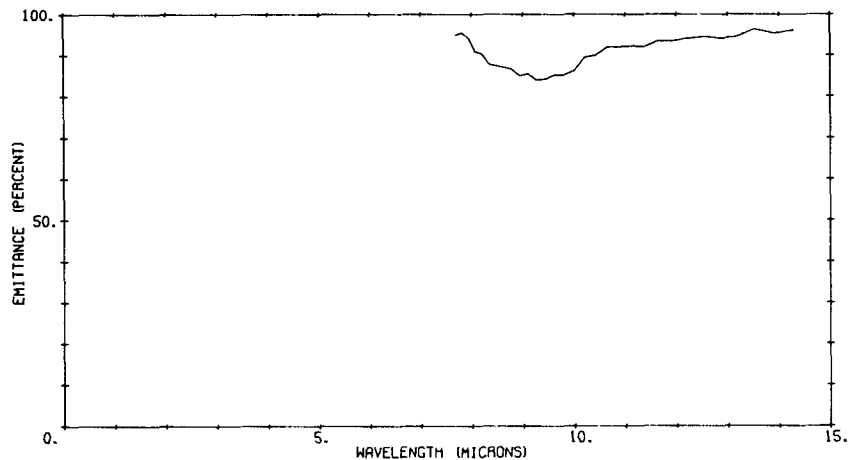
INTERMEDIATE SILICATE ROCKS

(Generally 53% to 65%  $\text{SiO}_2$ )

84

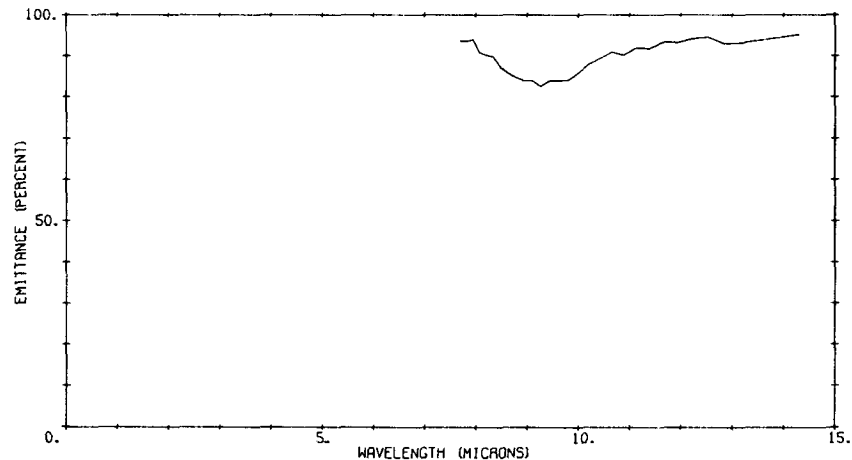
B09001 019

ANDESITE — BANDED ANDESITE WITH LARGE PHENOCRYSTS AND RED OXIDIZED BASALT-FRAGMENTS, GLASSY GROUNDMASS, SLIGHTLY GLOSSY NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



B09001 020

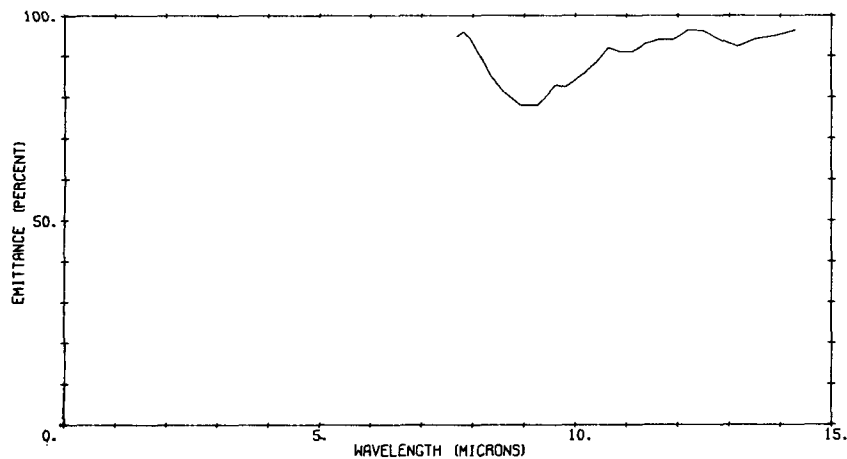
ANDESITE — BANDED ANDESITE WITH LARGE PHENOCRYSTS AND RED OXIDIZED BASALT-FRAGMENTS, GLASSY GROUNDMASS, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



100-1

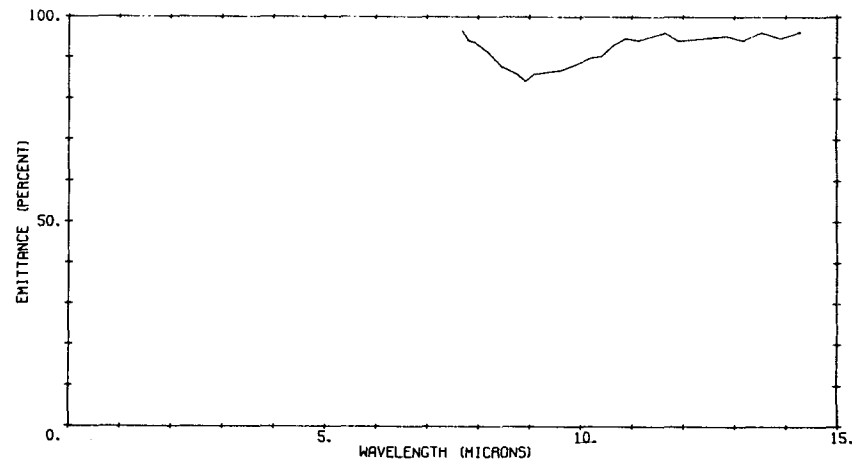
B09001 021

ANDESITE — GRAY, BANDED ANDESITE, LARGE FELDSPAR PHENOCRYSTS, DARK BASALT FRAGMENTS, GLASSY GROUNDMASS, SLIGHTLY GLOSSY NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



B09001 022

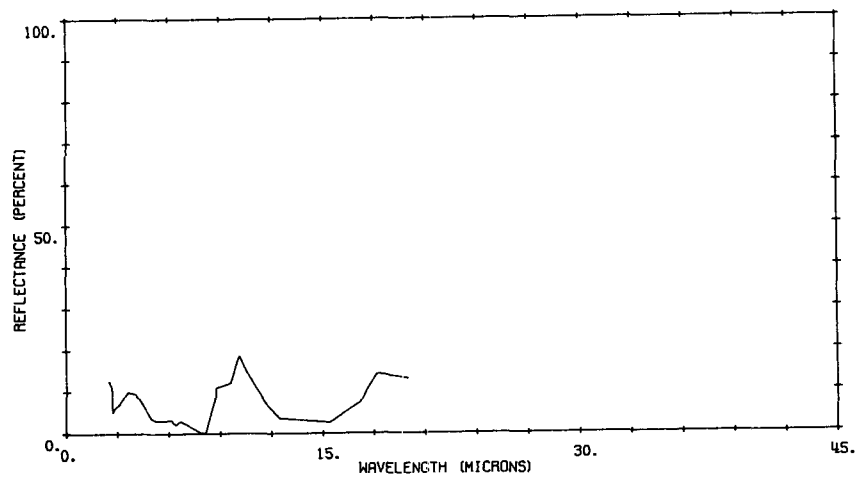
ANDESITE — GRAY, BANDED ANDESITE, LARGE FELDSPAR PHENOCRYSTS, DARK BASALT-FRAGMENTS, GLASSY GROUNDMASS, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



58  
57

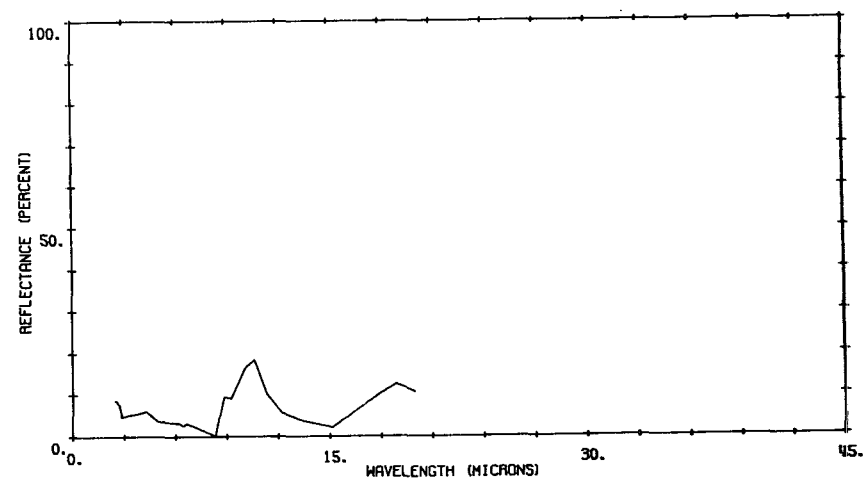
B09006 002

DIORITE (BAJA CALIFORNIA, MEXICO).



B09006 016

DIORITE WITH PYROXENE (BAJA CALIFORNIA, MEXICO).

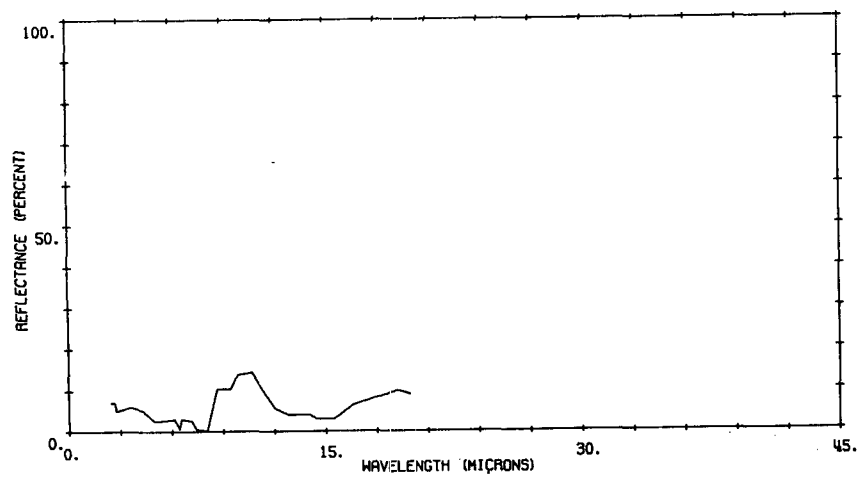


103-2

98

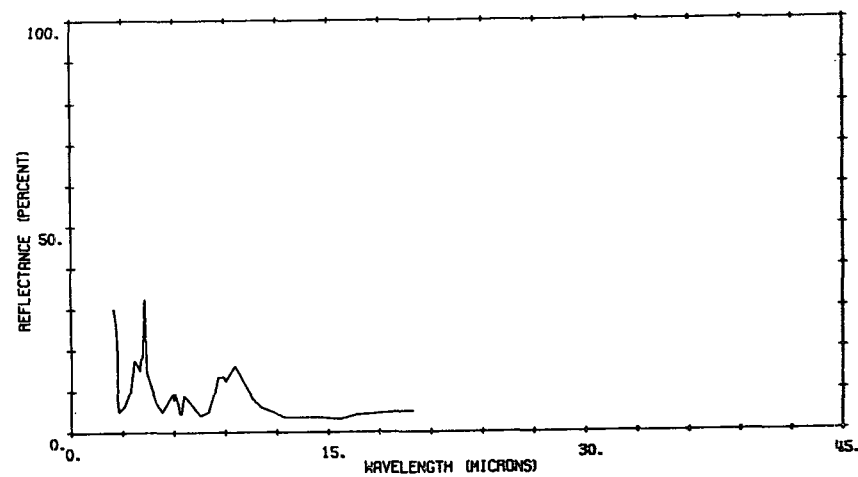
B09006 020

DIORITE PORPHYRY (BAJA CALIFORNIA, MEXICO).



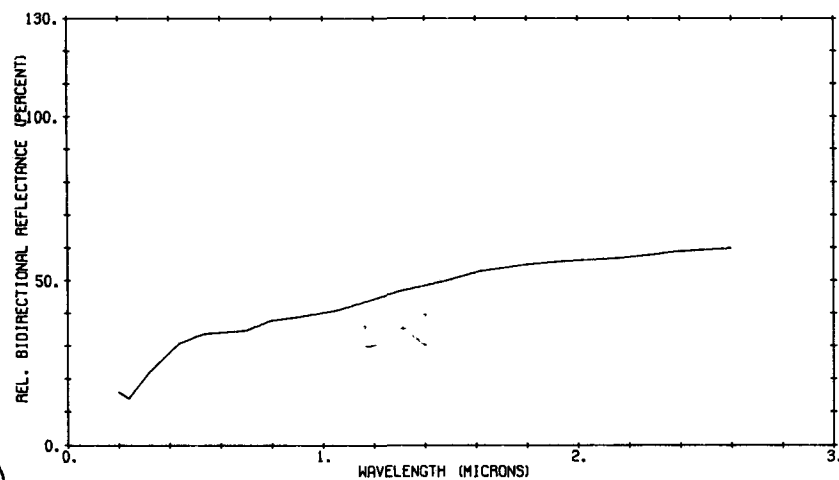
B09006 022

ANDESITE (BAJA CALIFORNIA, MEXICO).



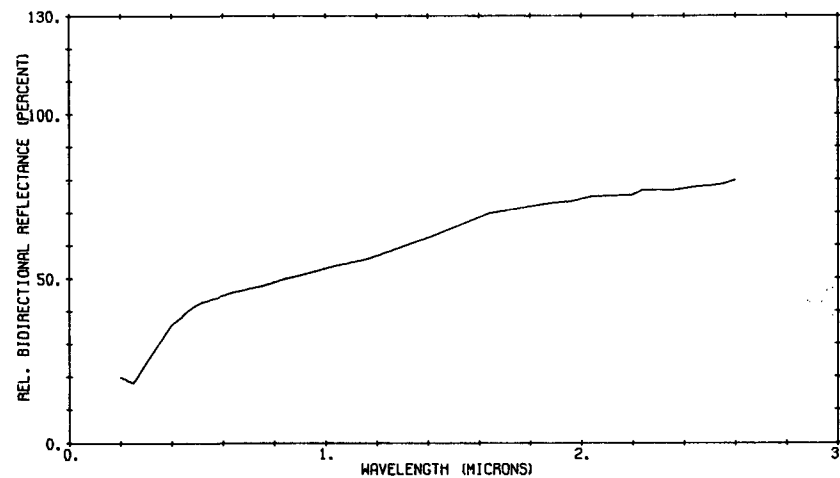
B09012 001

HORNBLende DIORITE (MASS.), PARTICLE DIAM.—0 TO 37 MICRONS.



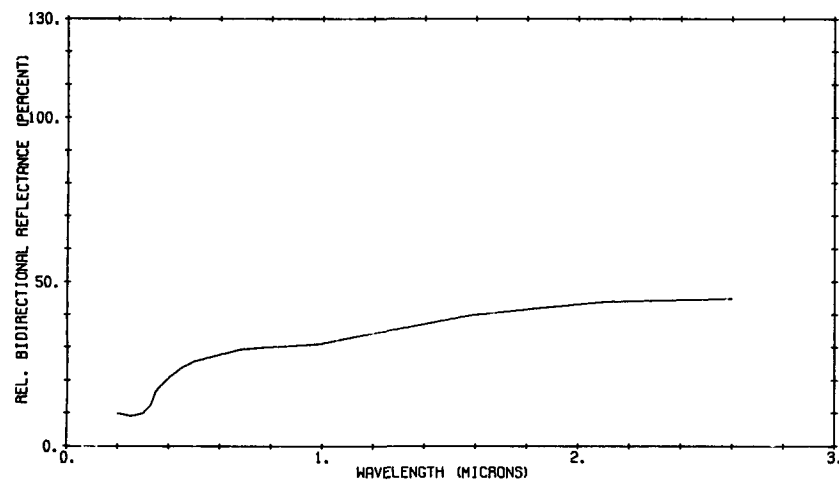
B09012 002

GRANODIORITE (MINN.), PARTICLE DIAMETER—0 TO 37 MICRONS.



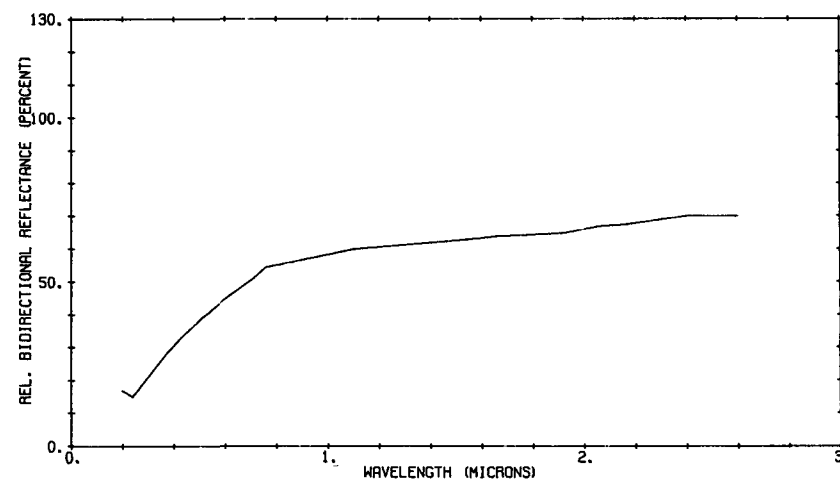
B09012 003

PORPHYRY DIORITE (QUEBEC), PARTICLE DIAM.—0 TO 37 MICRONS.



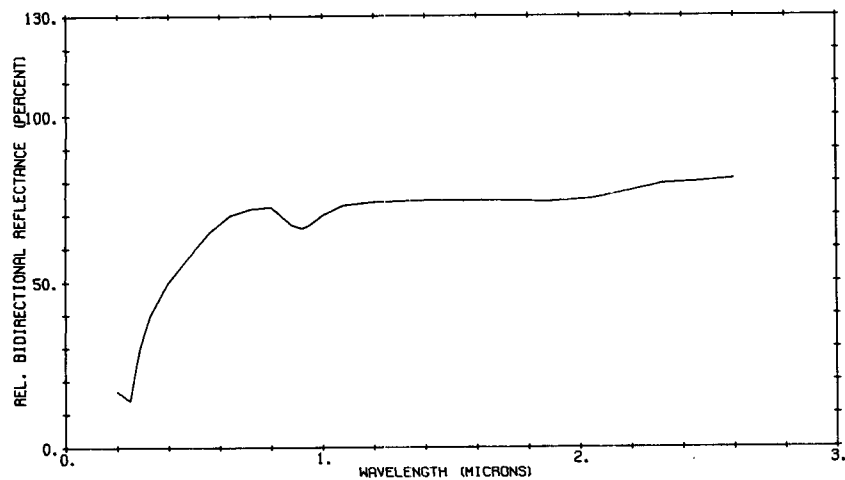
B09012 006

PORPHYRY ANDESITE (COL.), PARTICLE DIAM.—0 TO 37 MICRONS.



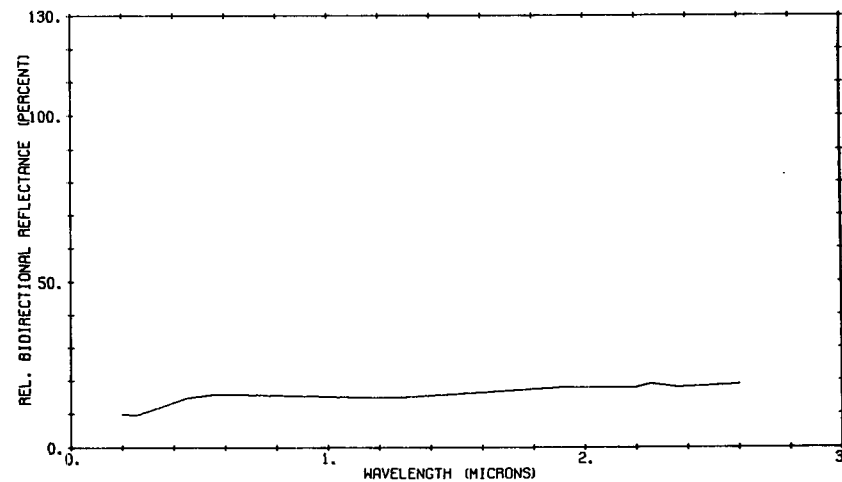
B09012 011

HORNBLLENDE ANDESITE (CALIF.), PARTICLE DIAM.—0 TO 37 MICRONS.



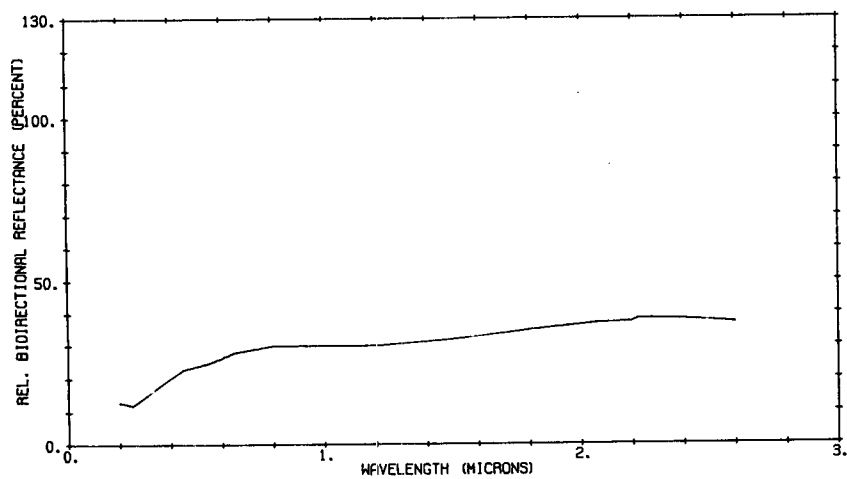
B09012 016

HORNBLLENDE DIORITE (MASS.), PARTICLE DIAMETER—420 TO 500 MICRONS.



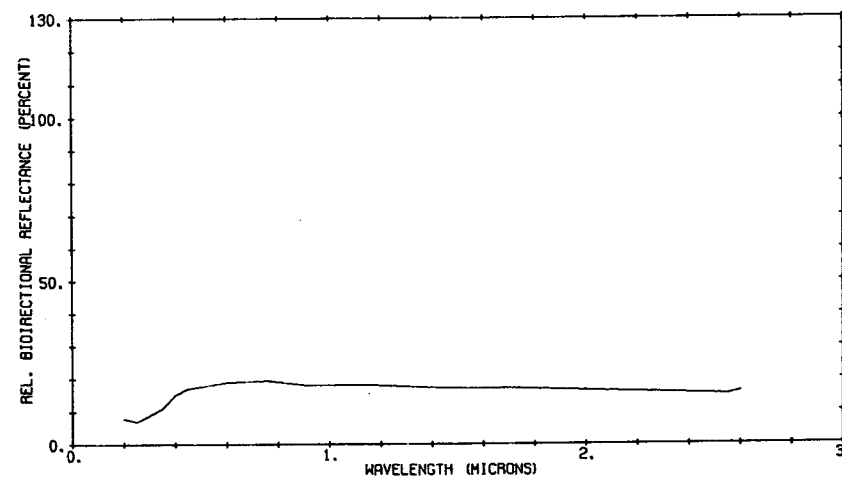
88 B09012 017

GRANODIORITE (MINN.), PARTICLE DIAM.—420 TO 500 MICRONS.



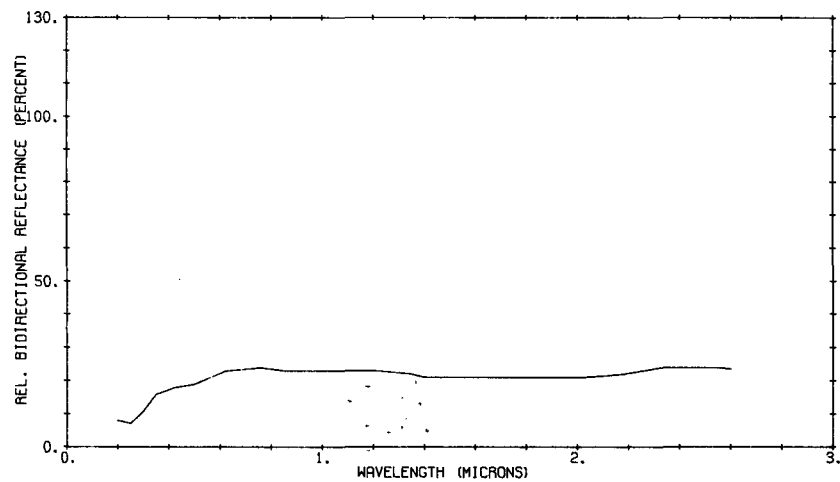
B09012 018

PORPHYRY DIORITE (QUEBEC), PARTICLE DIAM.—420 TO 500 MICRONS.



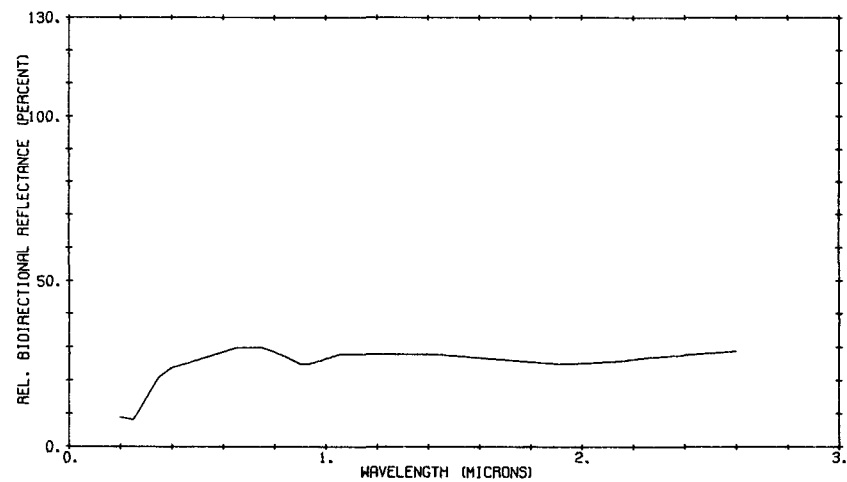
B09012 021

PORPHYRY ANDESITE (COL.), PARTICLE DIAM. — 420 TO 500 MICRONS.



B09012 026

HORNBLende ANDESITE (CALIF.), PARTICLE DIAM. — 420 TO 500 MICRONS.





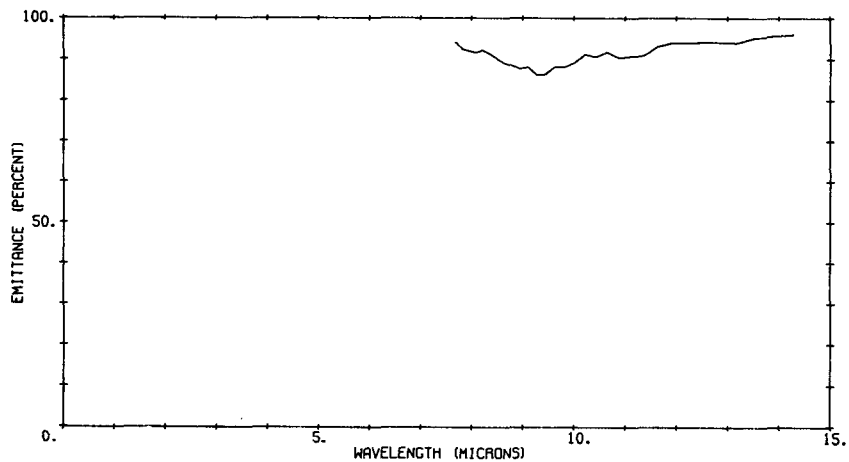
103

**BASIC AND ULTRABASIC SILICATE ROCKS**

(Generally Less Than 53%  $\text{SiO}_2$ )

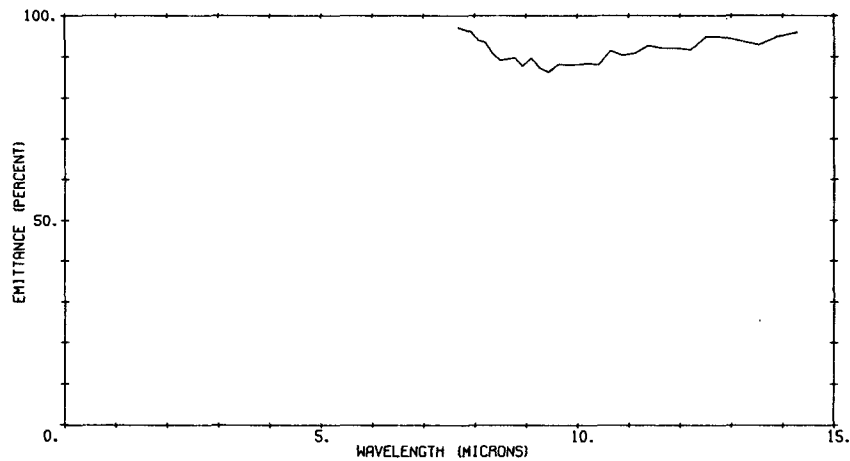
B09001 023

BASALT—BLACK, VESICULAR, PLAGIOCLASE BASALT, NATURALLY WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



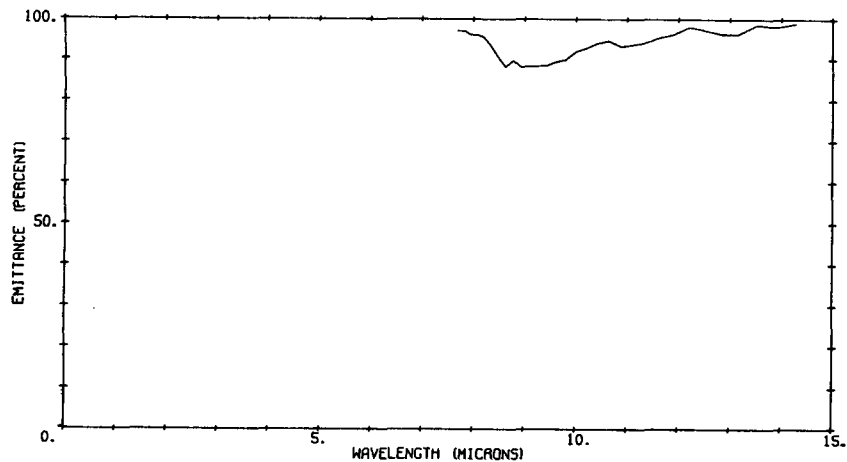
B09001 024

BASALT—BLACK, VESICULAR, PLAGIOCLASE BASALT, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



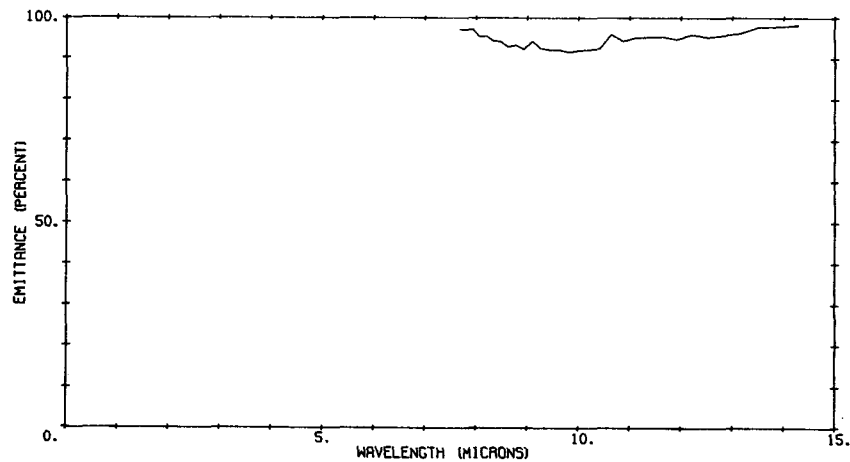
16  
B09001 025

BASALT—RED, OXIDIZED FLOW OF VESICULAR, PLAGIOCLASE BASALT, NATURAL WEATHERED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



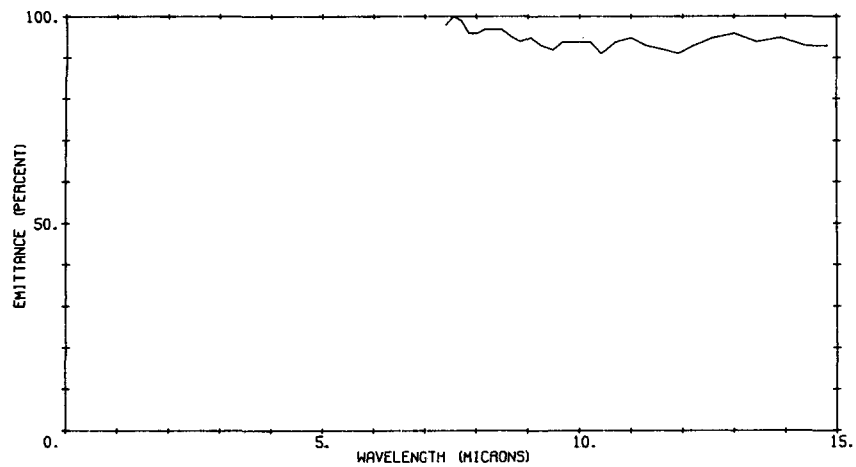
B09001 026

BASALT—RED, OXIDIZED FLOW OF VESICULAR, PLAGIOCLASE BASALT, SAWED SURFACE, (MONO CRATERS REGION, CALIFORNIA).



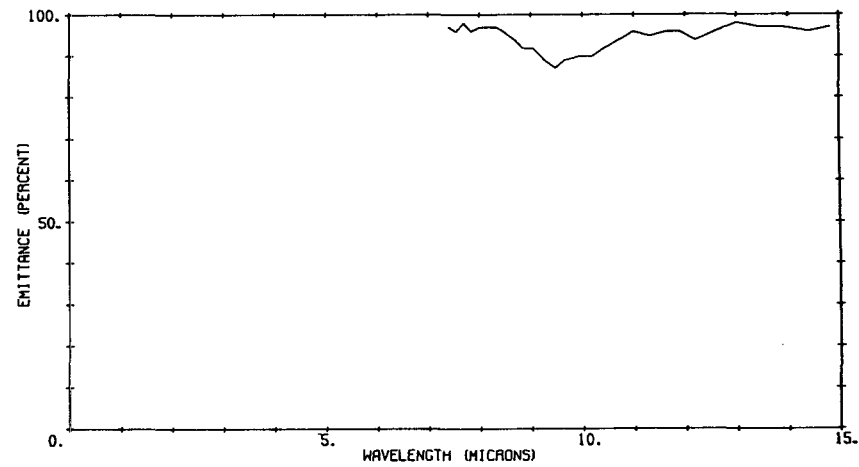
B09002 012

RED BASALT CINDER, WEATHERED SURFACE, (MONO CRATERS REGION,  
CALIFORNIA).



B09002 013

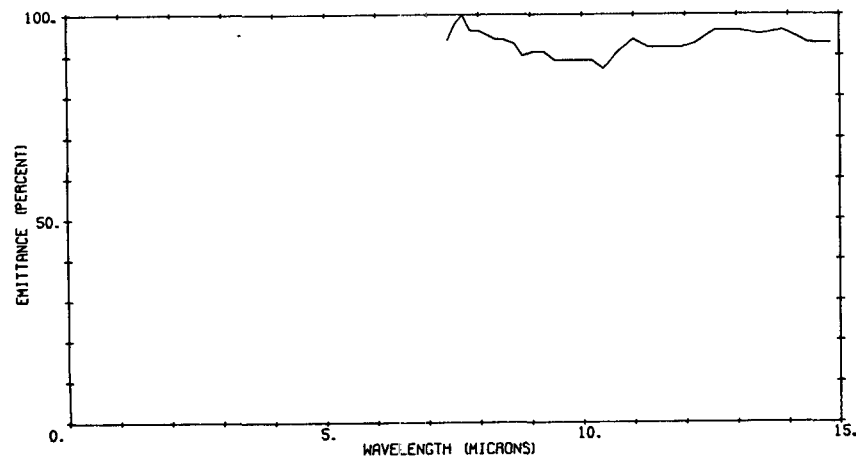
BASALT, PAHOEHOE, WEATHERED SURFACE, (PISGAH CRATER REGION,  
CALIFORNIA).



103-2

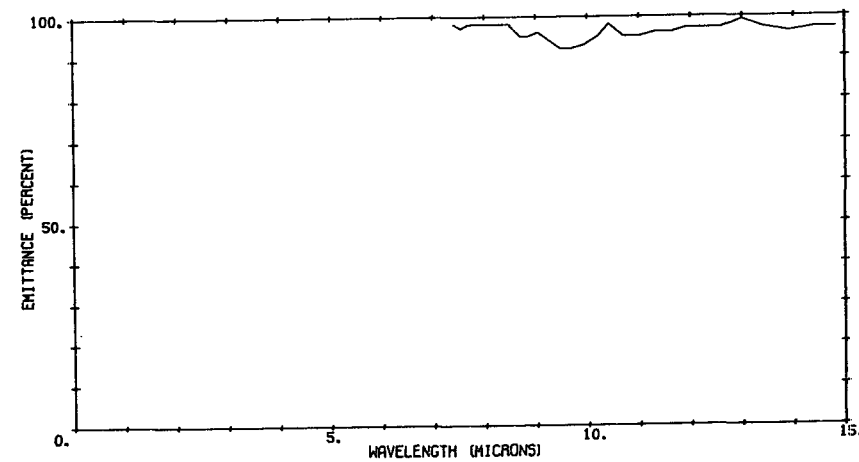
92 B09002 014

BASALT, PAHOEHOE, SAWED SURFACE, (PISGAH CRATER REGION,  
CALIFORNIA).



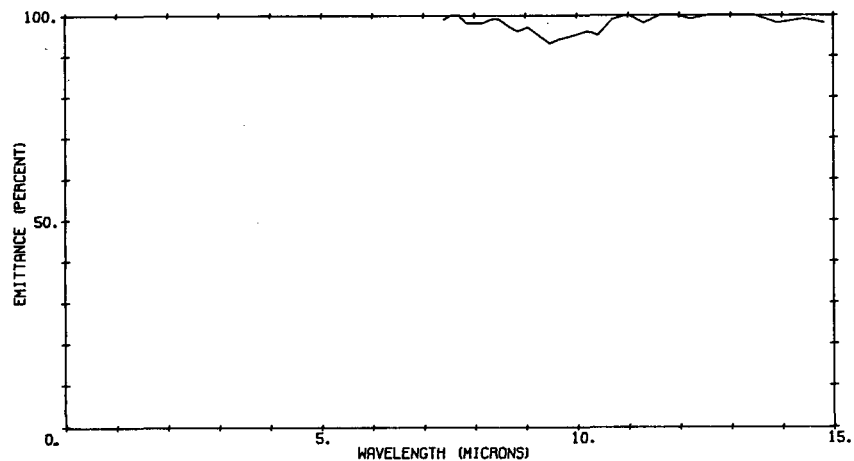
B09002 015

BASALT, AA, WEATHERED SURFACE, (PISGAH CRATER REGION IN  
CALIFORNIA).



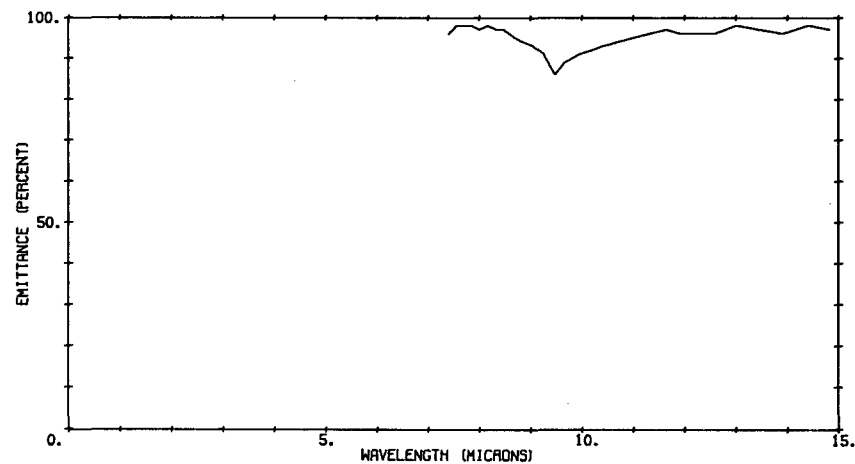
B09002 016

BASALT, AA, WEATHERED SURFACE, (PISGAH CRATER REGION IN CALIFORNIA).



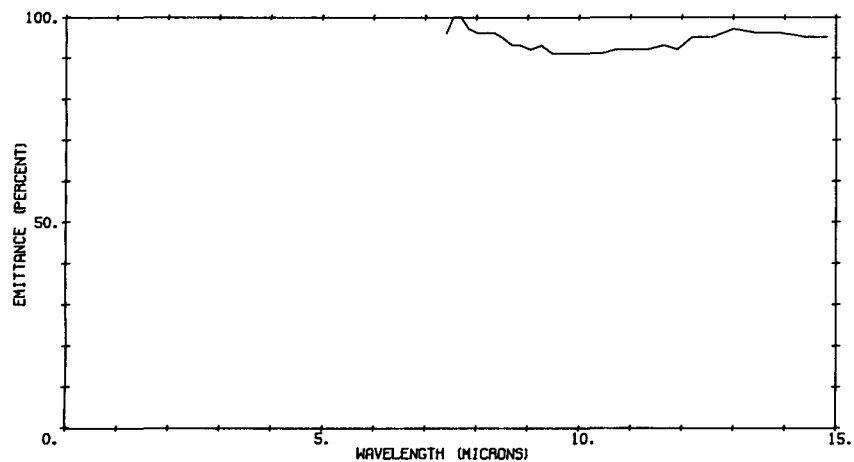
B09002 017

BASALT, AA, WEATHERED SURFACE, (PISGAH CRATER REGION IN CALIFORNIA).



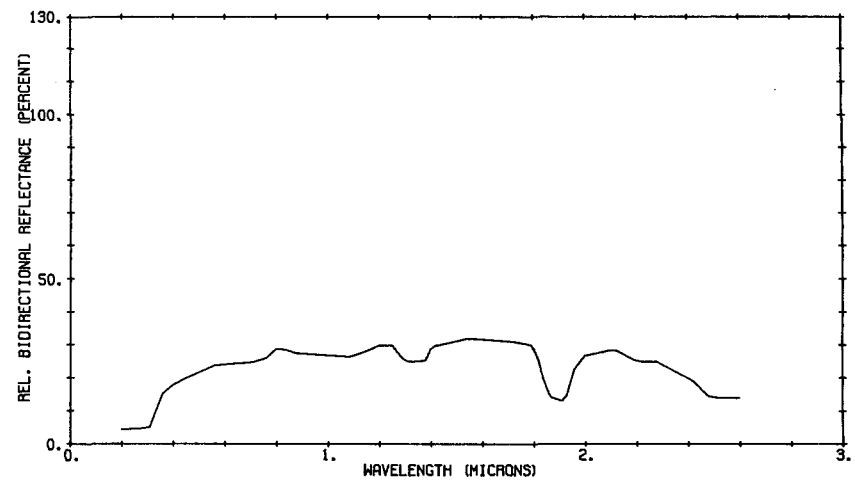
B09002 018

BASALT, AA, BROKEN SURFACE, (PISGAH CRATER REGION, CALIF.).



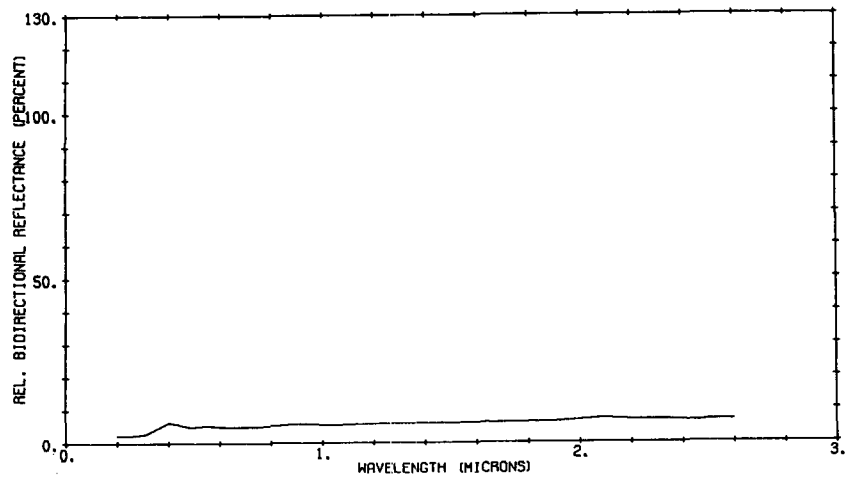
B09004 010

LAVA, WEATHERED (IRON OXIDE STAINED) SURFACE.



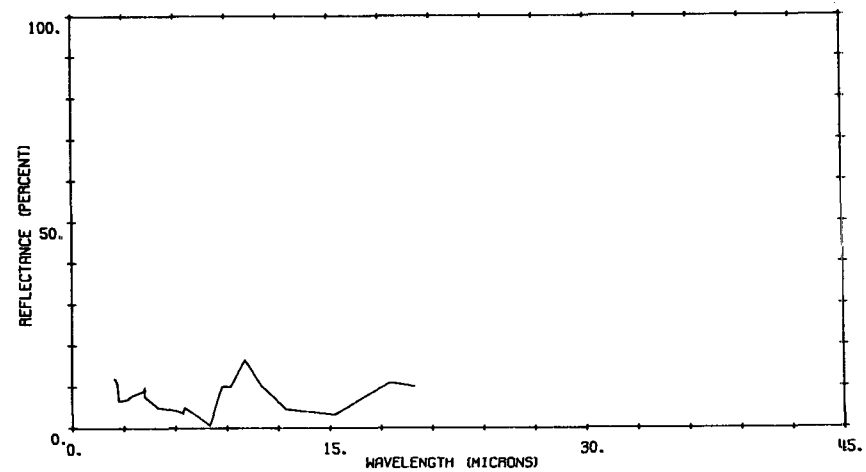
B09004 013

LAVA, UNWEATHERED SURFACE.



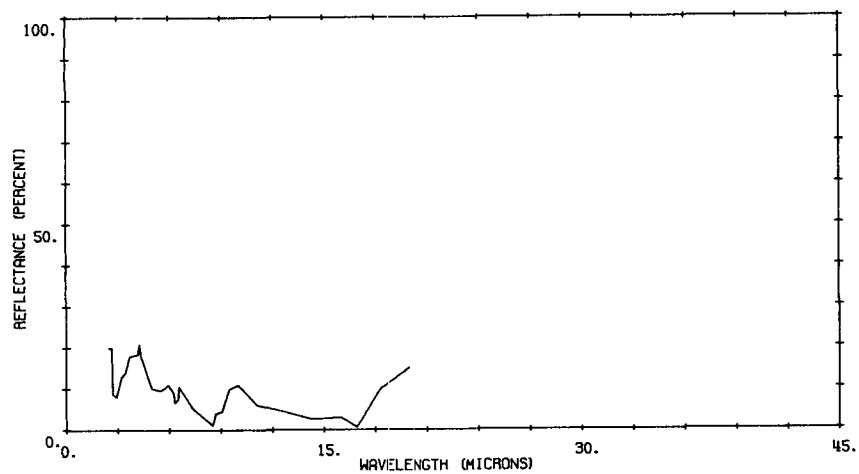
B09006 018

HORNBLende GABBRO (BAJA CALIFORNIA, MEXICO).



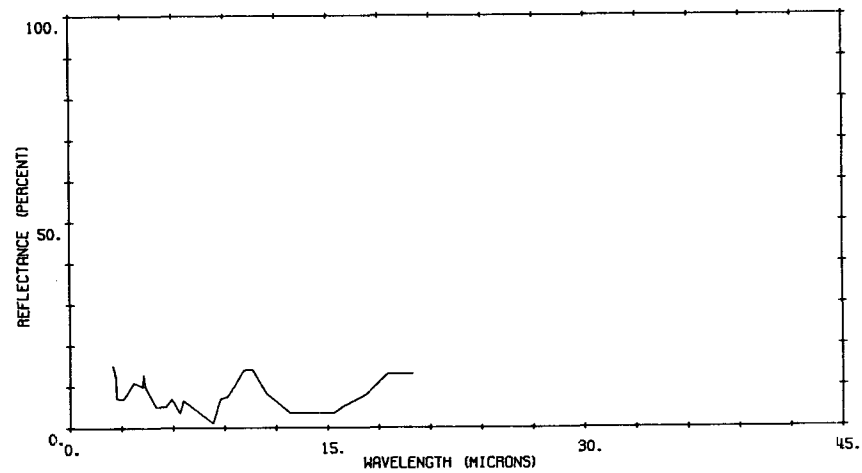
76 B09006 023

PYROXENITE (BAJA CALIFORNIA, MEXICO).



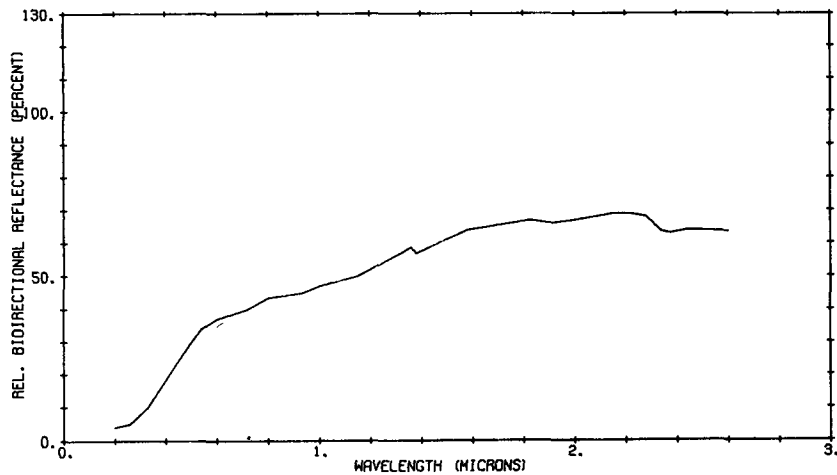
B09006 024

GABBRO (BAJA CALIFORNIA, MEXICO).



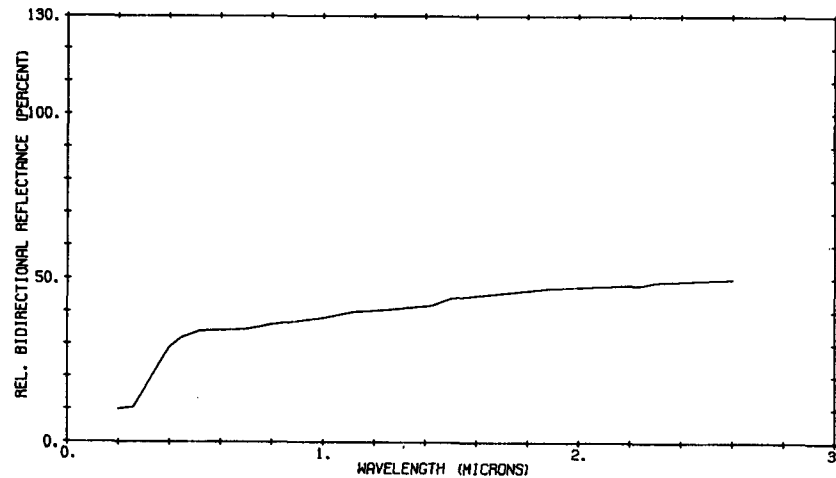
B09012 008

MICA-AUGITE PERIDOTITE (ARK.), PARTICLE DIAM.—0 TO 37 MICRONS.



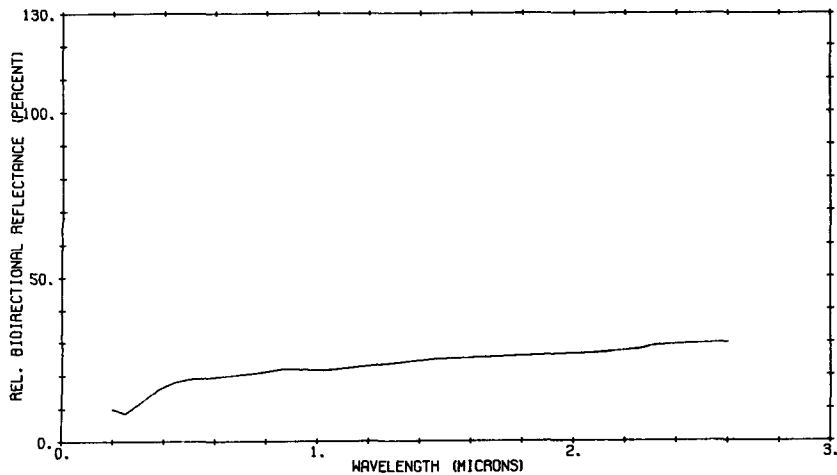
B09012 009

BYTOWNITE GABBRO (MINN.), PARTICLE DIAM.—0 TO 37 MICRONS.



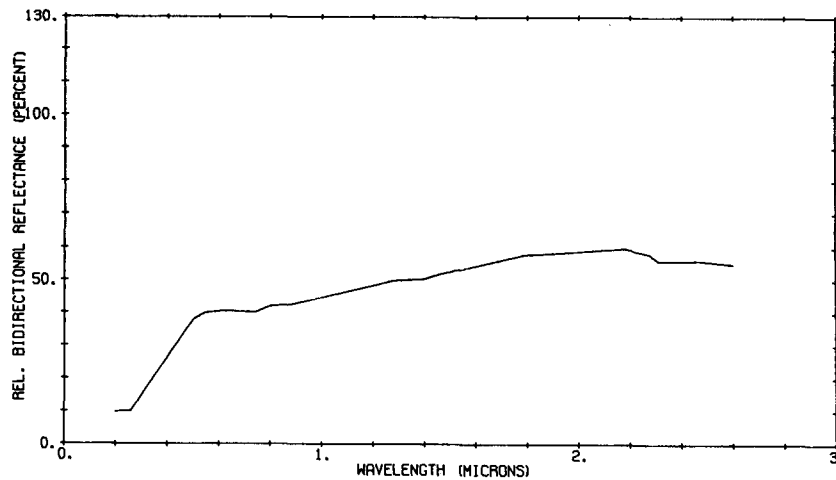
56  
B09012 013

BASALT (OREGON), PARTICLE DIAM.—0 TO 37 MICRONS.



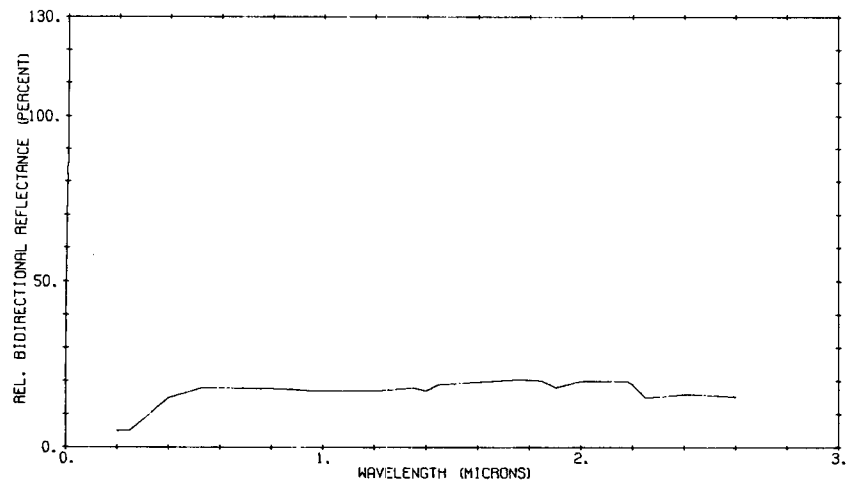
B09012 015

PERIDOTITE-SERPENTINITE (N.Y.), PARTICLE DIAM.—0 TO 37 MICRONS.



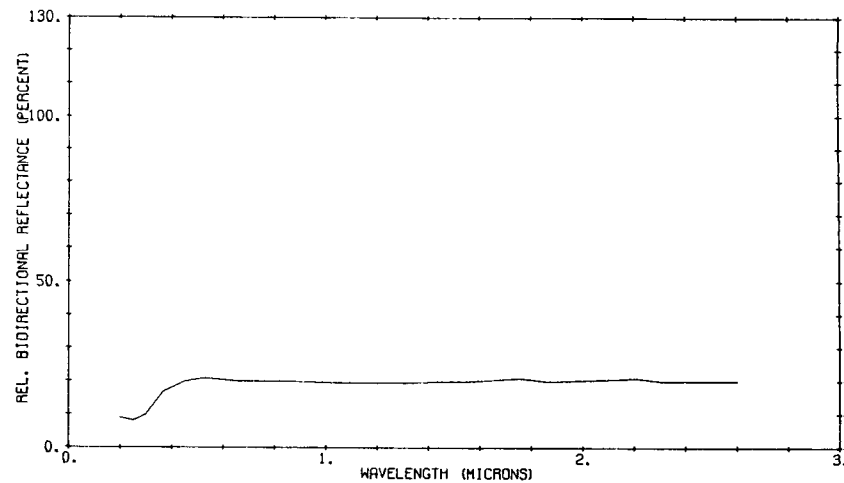
B09012 023

MICA-AUGITE PERIDOTITE (ARK.), PARTICLE DIAM.—420 TO 500 MIC.



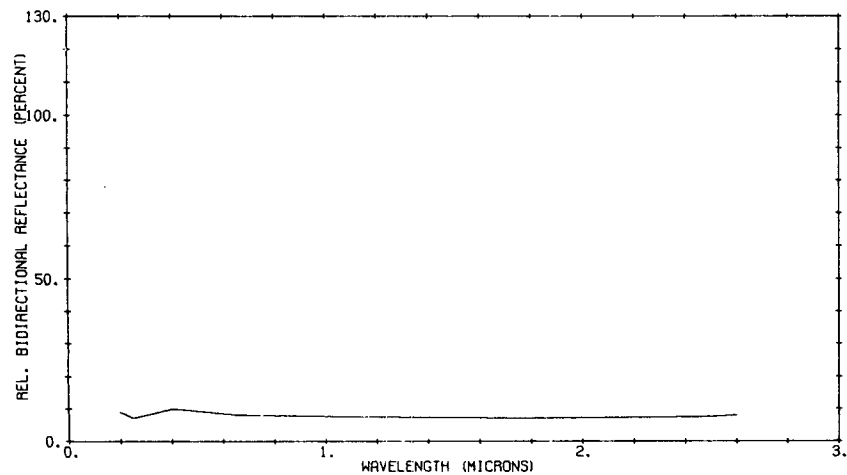
B09012 024

BYTOWNITE GABBRO (MINN.), PARTICLE DIAM.—420 TO 500 MICRONS.



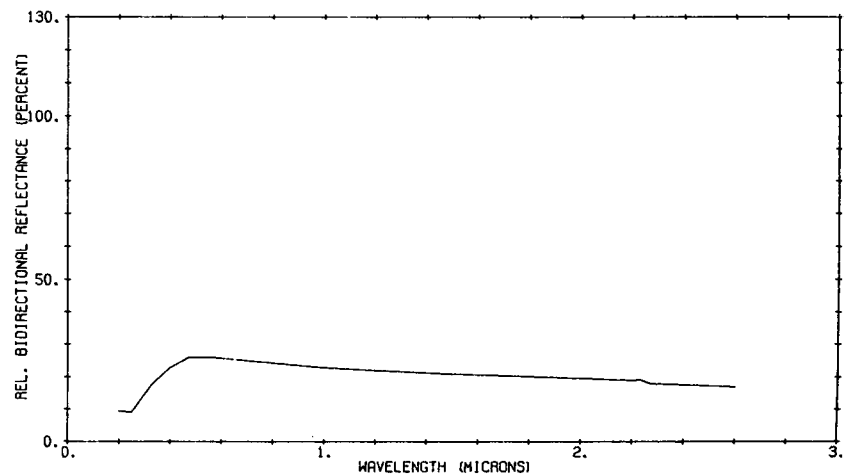
06 B09012 028

BASALT (OREGON), PARTICLE DIAM.—420 TO 500 MICRONS.



B09012 030

PERIDOTITE-SERPENTINITE (N.Y.), PARTICLE DIAMETER—420 TO 500 MICRONS.



110

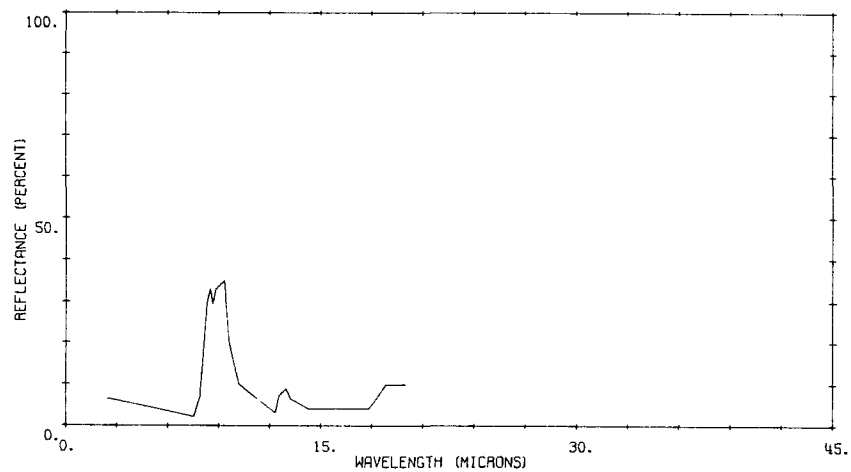
SEDIMENTARY AND METAMORPHIC ROCKS

97



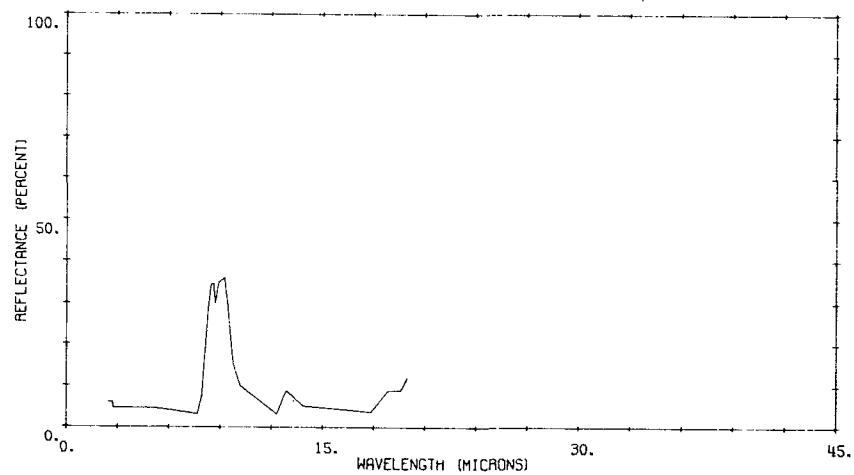
B09006 010

CARBONACEOUS FILITE (BAJA CALIFORNIA, MEXICO).



B09006 011

CARBONACEOUS FILITE (BAJA CALIFORNIA, MEXICO).



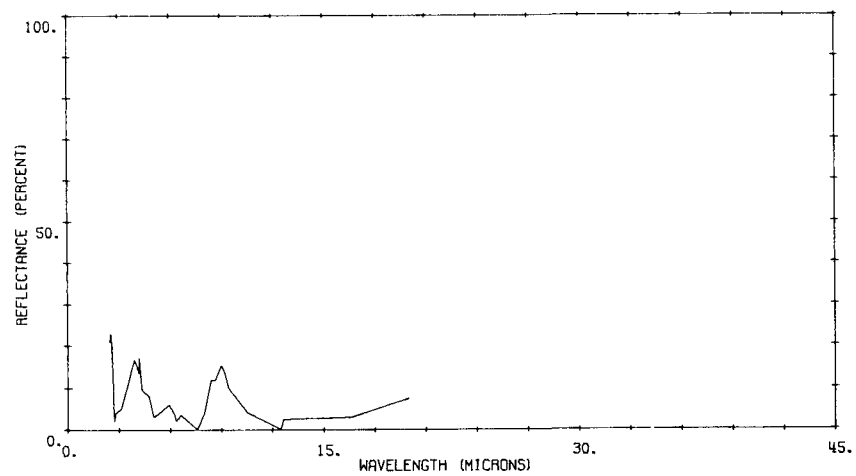
86

111

SILICATE SEDIMENTARY  
AND METAMORPHIC ROCKS

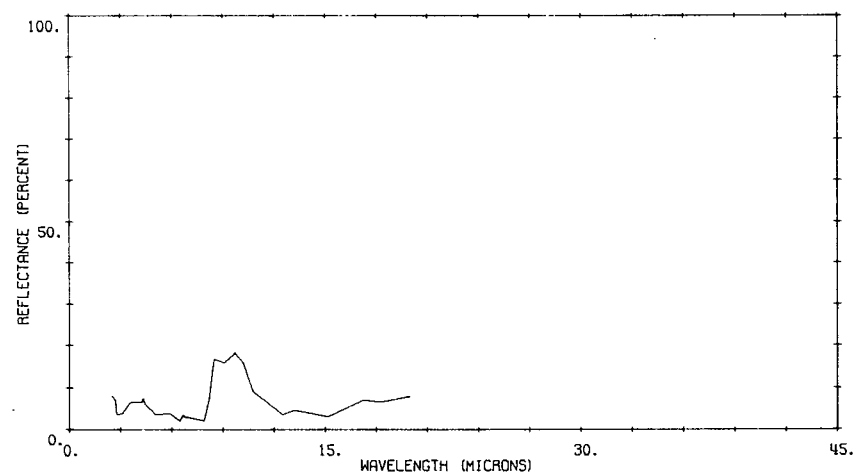
001  
B09006 014

QUARTZITE (ENSENADA, BAJA CALIFORNIA, MEXICO).



B09006 017

SANDSTONE (BAJA CALIFORNIA, MEXICO).



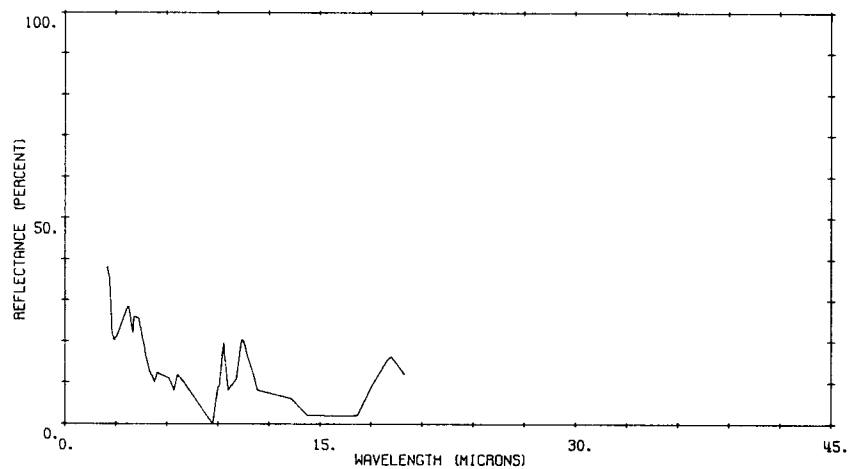
112

CARBONATE SEDIMENTARY  
AND METAMORPHIC ROCKS

101

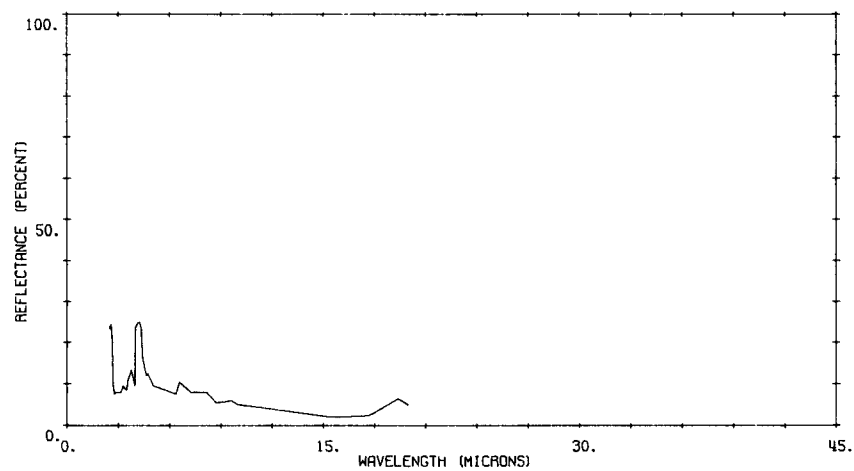
809006 003

SKARN (GULF OF TEHUANTEPEC, MEXICO).



809006 021

CALCARENITE (ANGANGUEO, MICHOACAN, MEXICO).



102

121

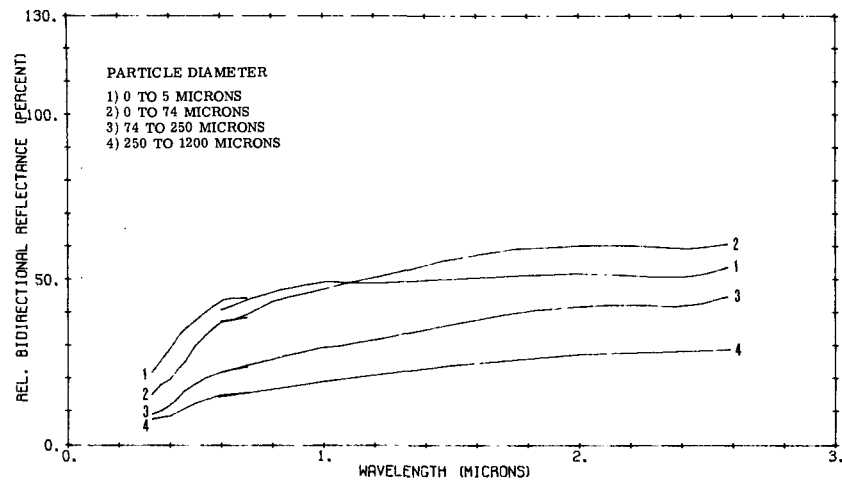
SILICATE MINERALS

(Associated Primarily with Acidic Rocks)

103

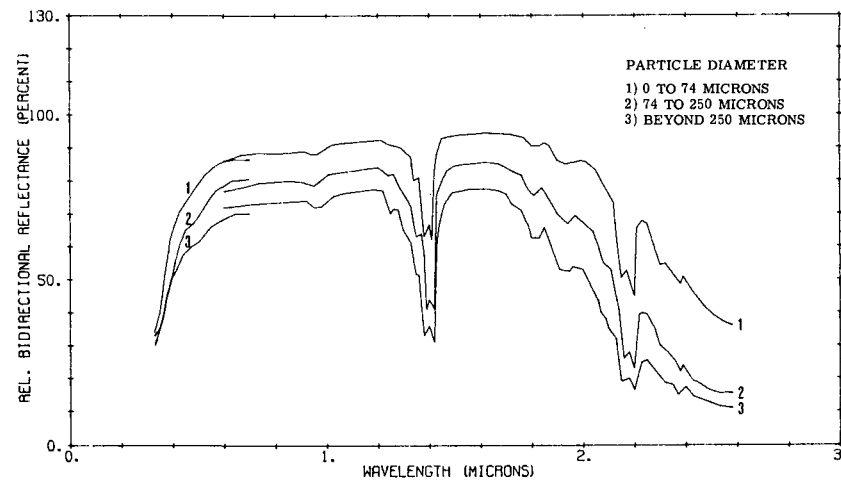
# ANORTHOCLASE FELDSPAR (LARVIK, NORWAY)

1) B09000 033, 2) B09000 034, 3) B09000 035, 4) B09000 036



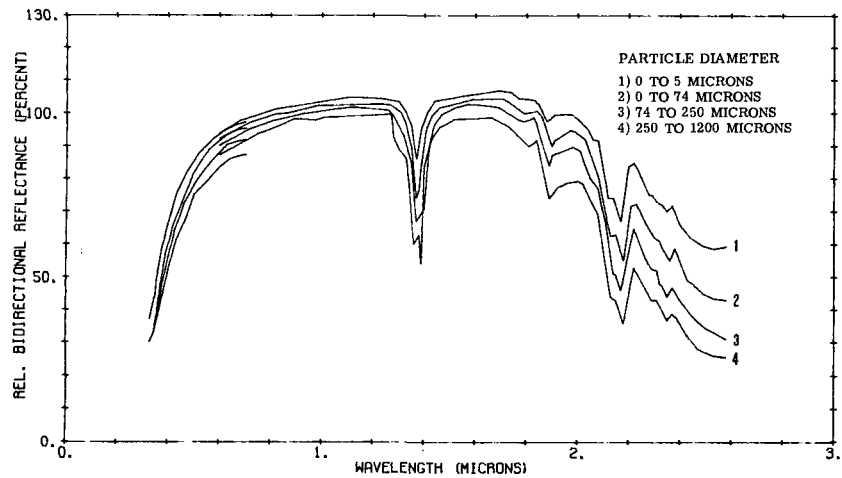
# KAOLINITE (MESA ALTA, NEW MEXICO)

1) B09000 061, 2) B09000 062, 3) B09000 063



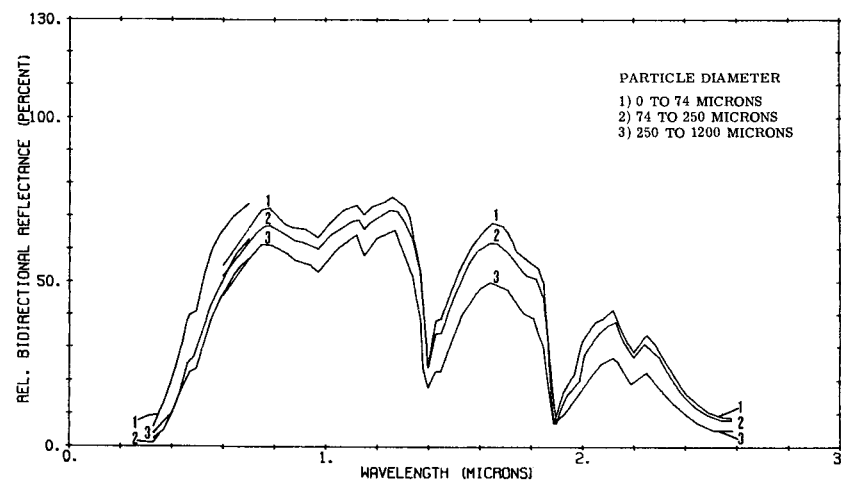
# KAOLINITE (MACON, GEORGIA)

1) B09000 068, 2) B09000 069, 3) B09000 070, 4) B09000 071



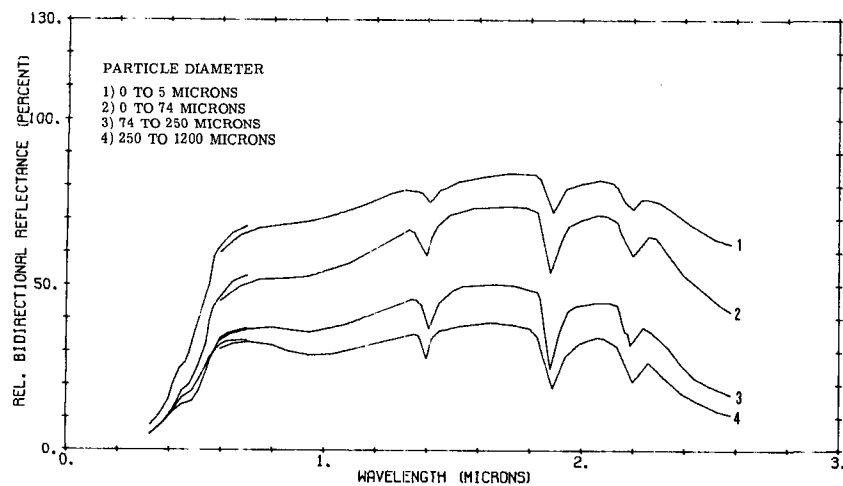
# MONTMORILLONITE (POLKVILLE, MISSISSIPPI)

1) B09000 072, 2) B09000 073, 3) B09000 074



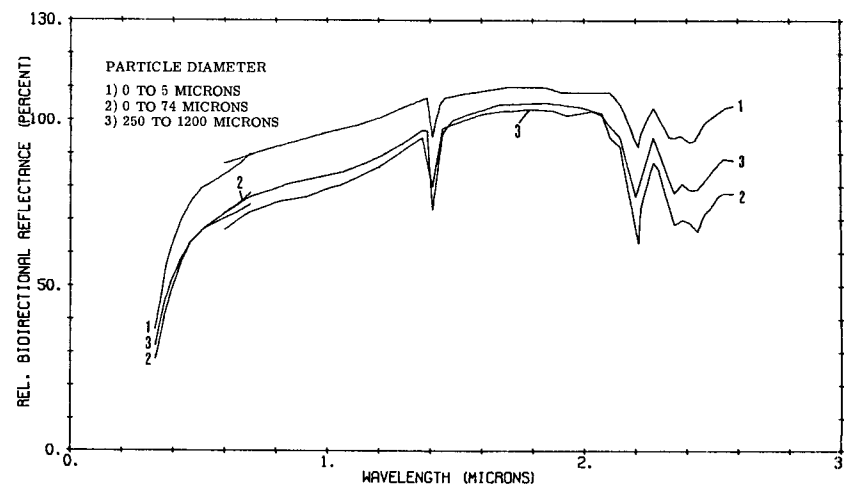
MONTMORILLONITE (ARMORY, MISSISSIPPI)

1) B09000 075, 2) B09000 076, 3) B09000 077, 4) B09000 078



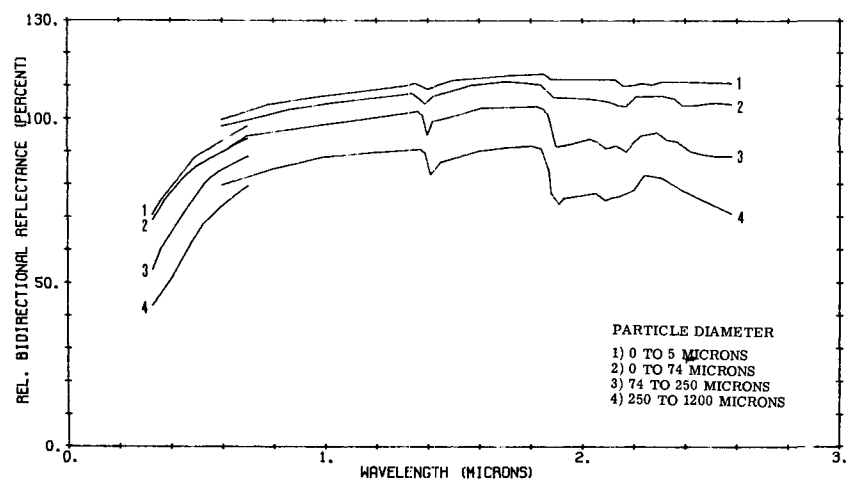
MUSCOVITE (EFFINGHAM TOWNSHIP, ONTARIO)

1) B09000 079, 2) B09000 080, 3) B09000 081



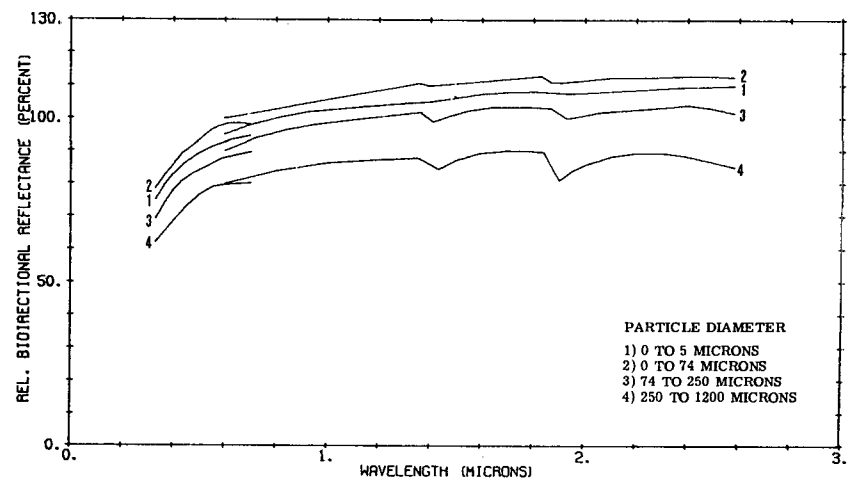
ORTHOCLASE (RUGGLES MINE, NEW HAMPSHIRE)

1) B09000 100, 2) B09000 101, 3) B09000 102, 4) B09000 103



PLAGIOCLASE (AMELIA, VIRGINIA) VARIETY ALBITE

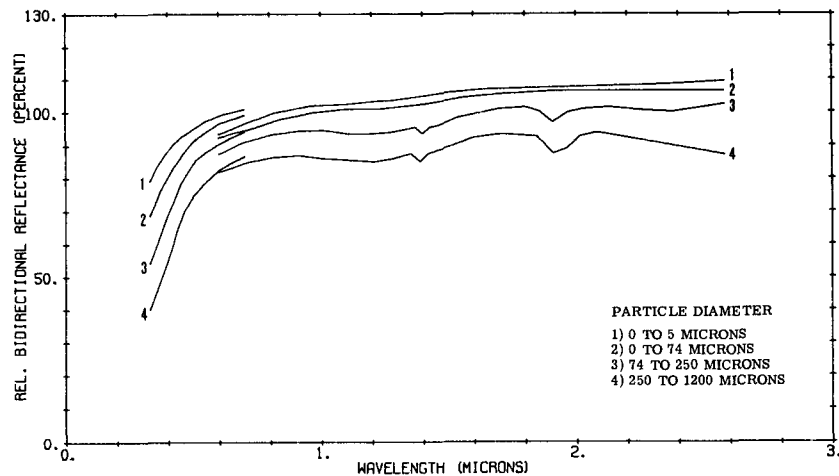
1) B09000 105, 2) B09000 104, 3) B09000 106, 4) B09000 107





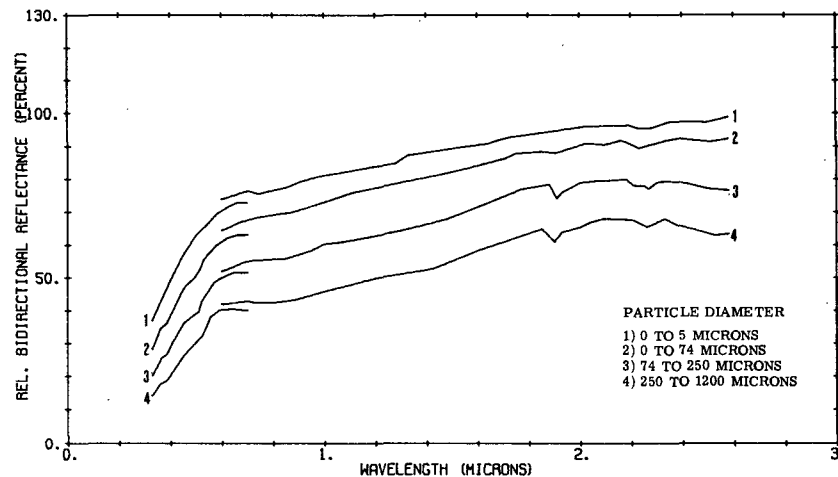
PLAGIOCLASE (NORWAY) VARIETY OLIGOCASE

1) B09000 108, 2) B09000 109, 3) B09000 110, 4) B09000 111



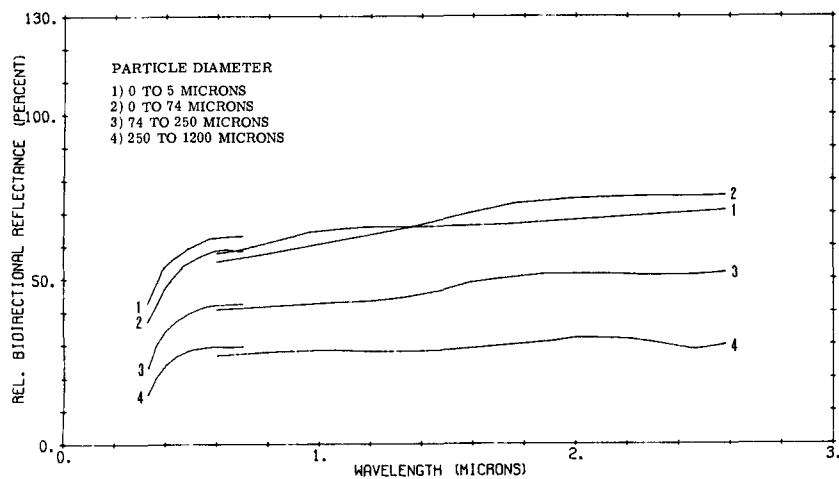
PLAGIOCLASE (MONTANA) VARIETY ANDESINE (IMPURE)

1) B09000 112, 2) B09000 113, 3) B09000 114, 4) B09000 115



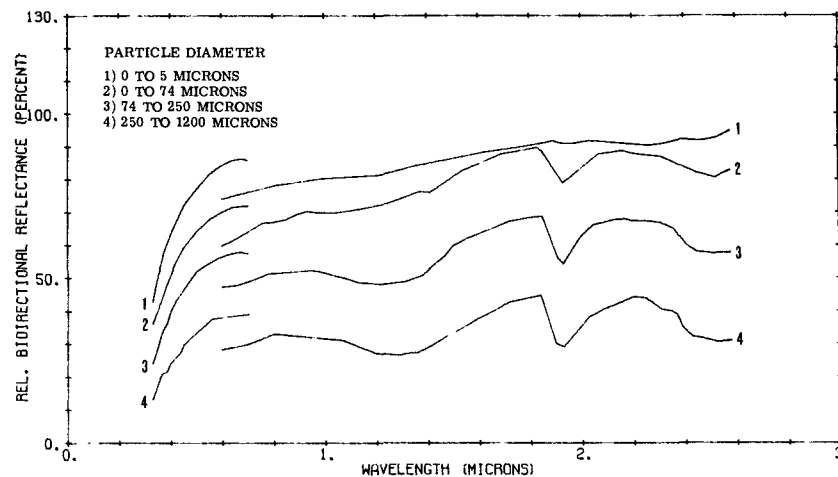
PLAGIOCLASE (ESSEX COUNTY, NEW YORK) VARIETY LABRADORITE

1) B09000 116, 2) B09000 117, 3) B09000 118, 4) B09000 119

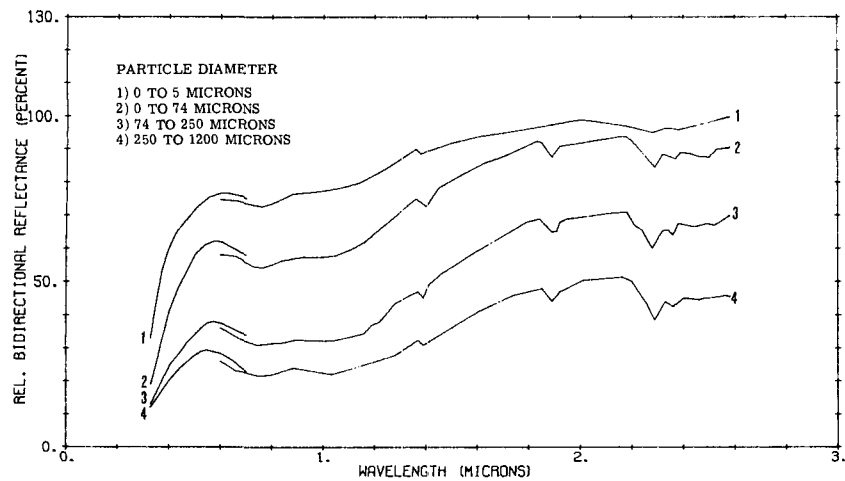


PLAGIOCLASE (CRYSTAL BAY, MINNESOTA) VARIETY BYTOWNITE

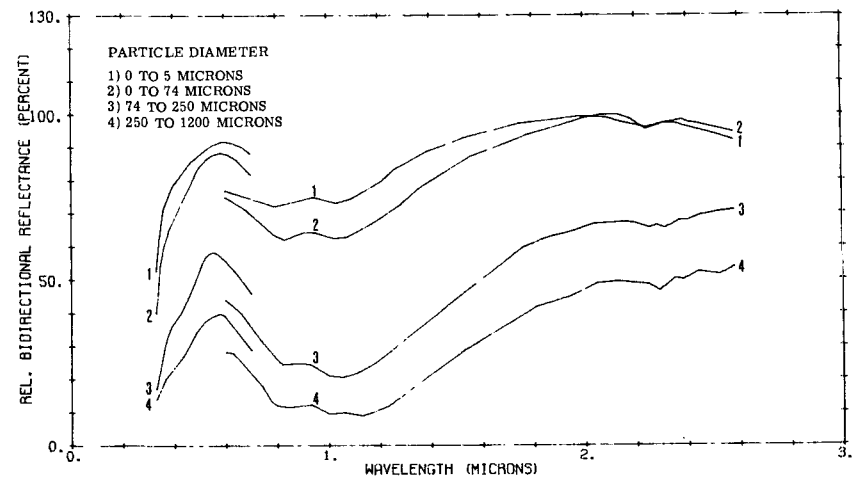
1) B09000 120, 2) B09000 121, 3) B09000 122, 4) B09000 123



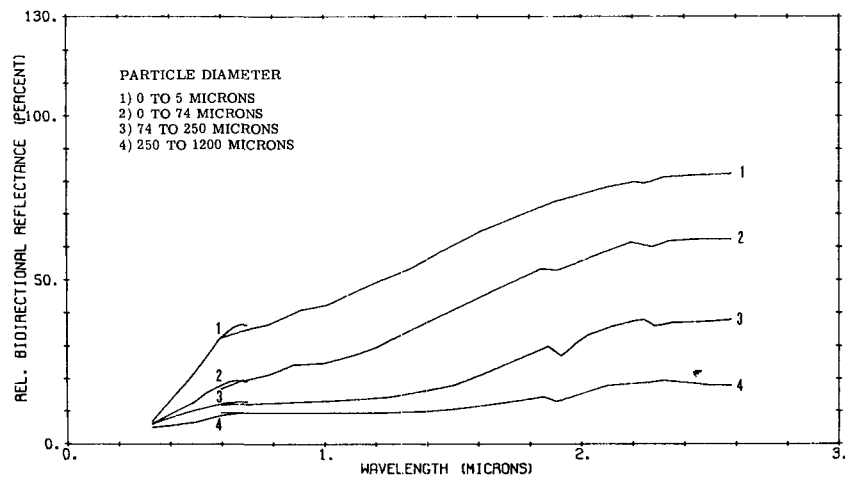
PYROXENE (QUEBEC, CANADA), VARIETY AUGITE  
1) B09000 124, 2) B09000 125, 3) B09000 126, 4) B09000 127



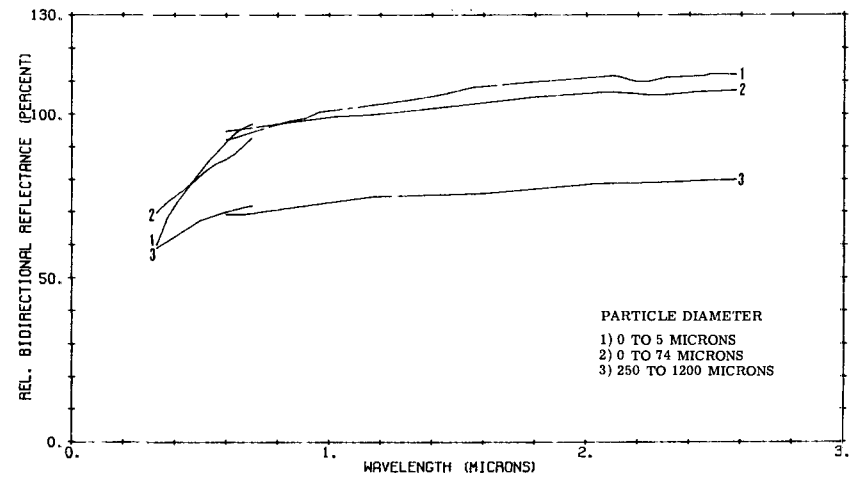
PYROXENE (EDWARDS, NEW YORK), VARIETY DIOPSIDE  
1) B09000 128, 2) B09000 129, 3) B09000 130, 4) B09000 131



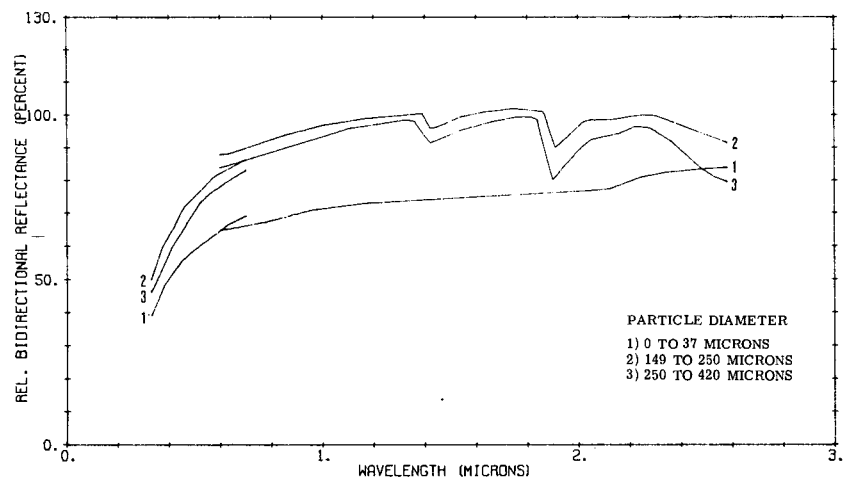
107  
PYROXENE (SILVER STAR, MONTANA), VARIETY HEDENBURGITE  
1) B09000 132, 2) B09000 133, 3) B09000 134, 4) B09000 135



QUARTZ 1) B09000 143, 2) B09000 144, 3) B09000 145

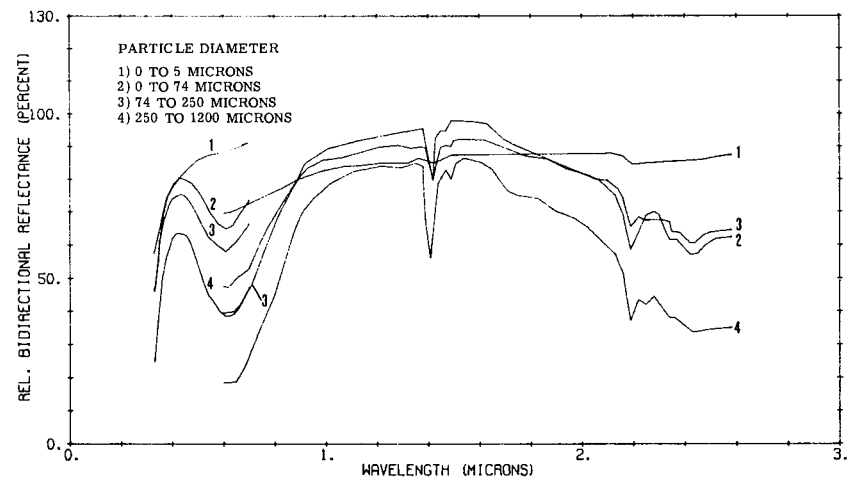


MILKY QUARTZ 1) B09000 148, 2) B09000 146, 3) B09000 147



ADVENTURINE QUARTZ (INDIA)

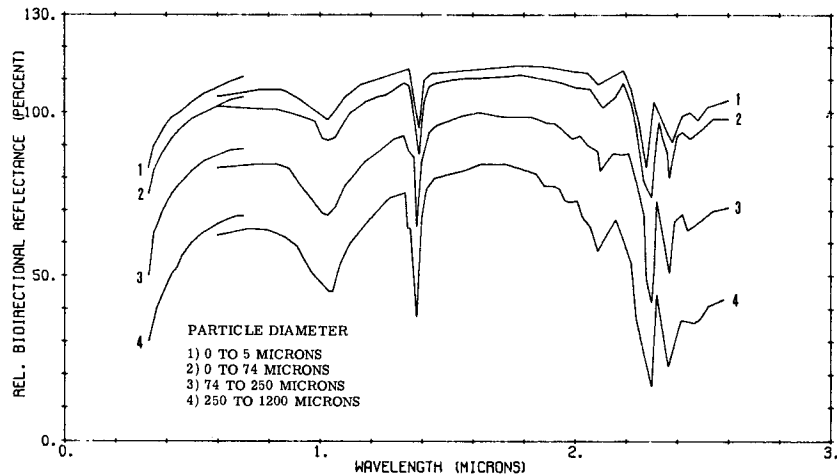
1) B09000 149, 2) B09000 150, 3) B09000 151, 4) B09000 152



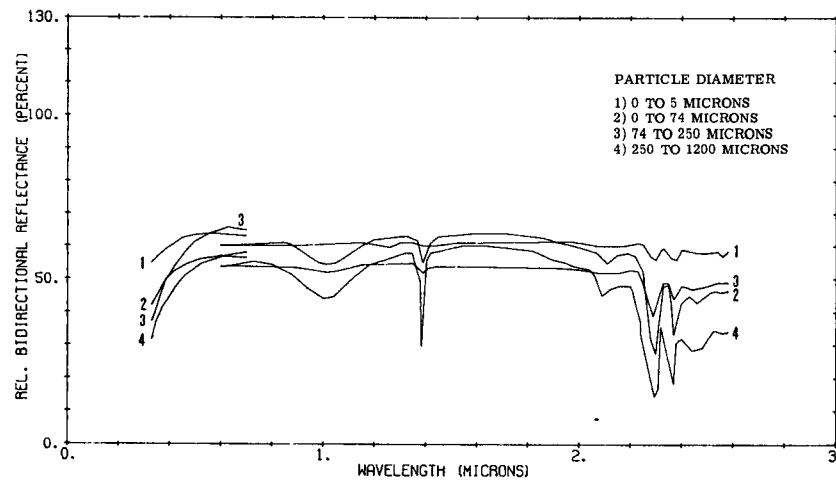
122

**FERROMAGNESIAN MINERALS**  
(Associated Primarily with Basic Rocks)

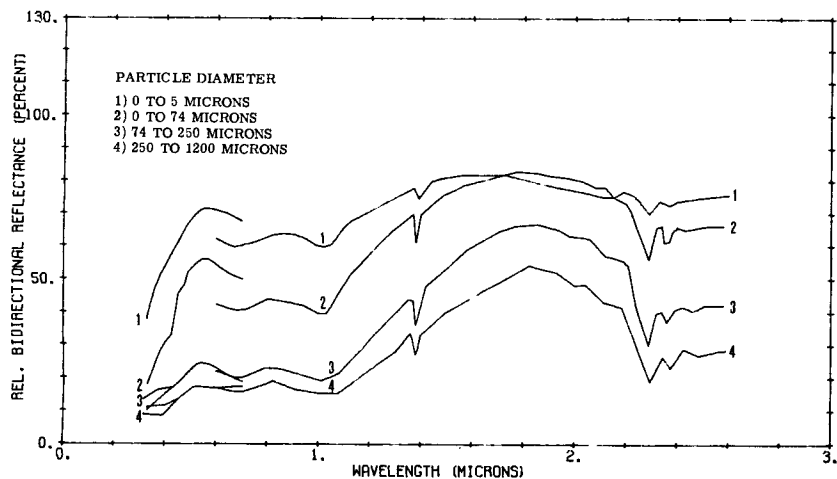
AMPHIBOLE (ST. LAWRENCE COUNTY, NEW YORK), VARIETY TREMOLITE  
1) B09000 001, 2) B09000 002, 3) B09000 003, 4) B09000 004



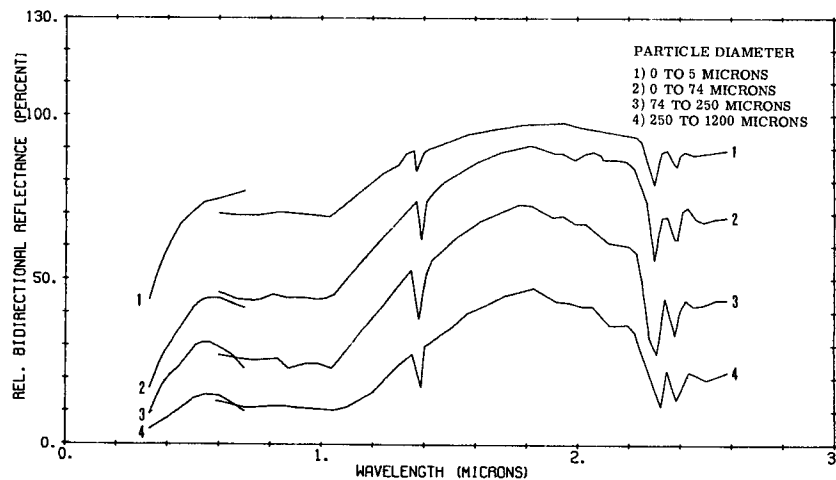
AMPHIBOLE (ST. LAWRENCE COUNTY, NEW YORK), VARIETY TREMOLITE  
1) B09000 005, 2) B09000 006, 3) B09000 007, 4) B09000 008



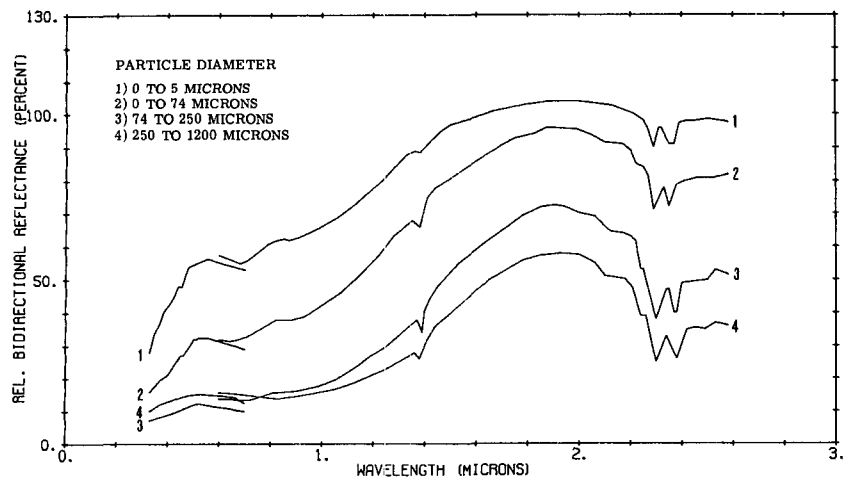
AMPHIBOLE (CHESTER, VERMONT), VARIETY ACTINOLITE  
1) B09000 009, 2) B09000 010, 3) B09000 011, 4) B09000 012



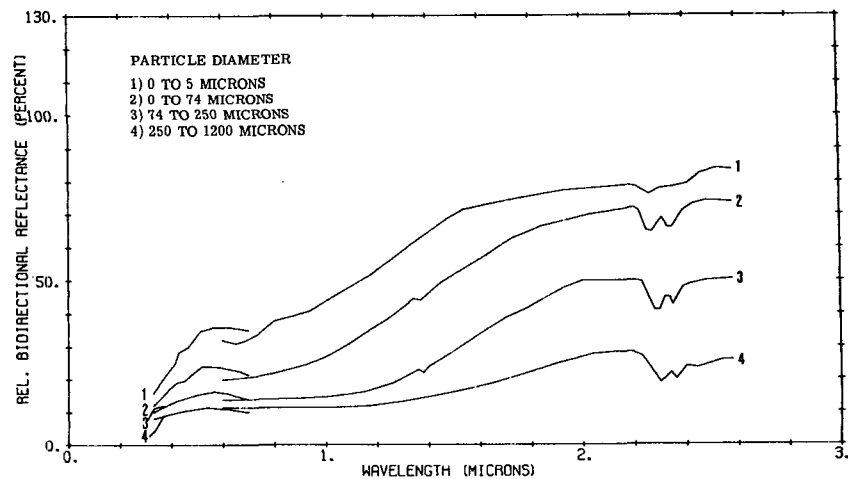
AMPHIBOLE (SAN BERNADINO, CALIFORNIA), VARIETY ACTINOLITE  
1) B09000 013, 2) B09000 014, 3) B09000 015, 4) B09000 016



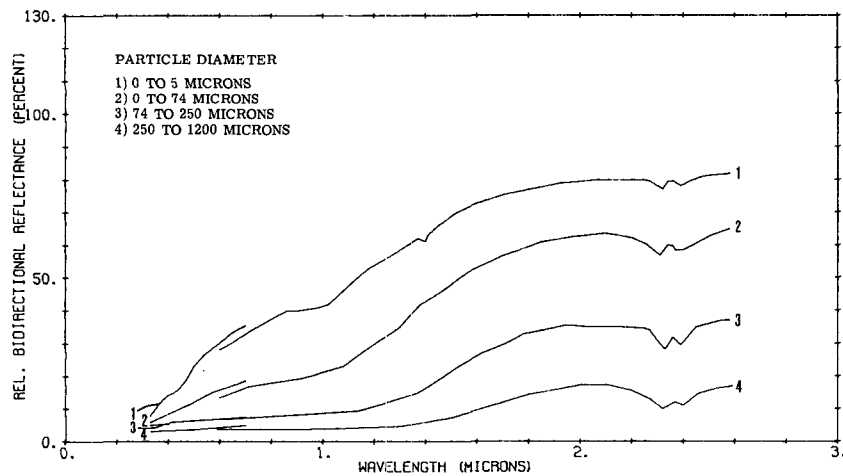
AMPHIBOLE (BREWSTER, NEW YORK), VARIETY HORNBLENDE  
1) B09000 017, 2) B09000 018, 3) B09000 019, 4) B09000 020



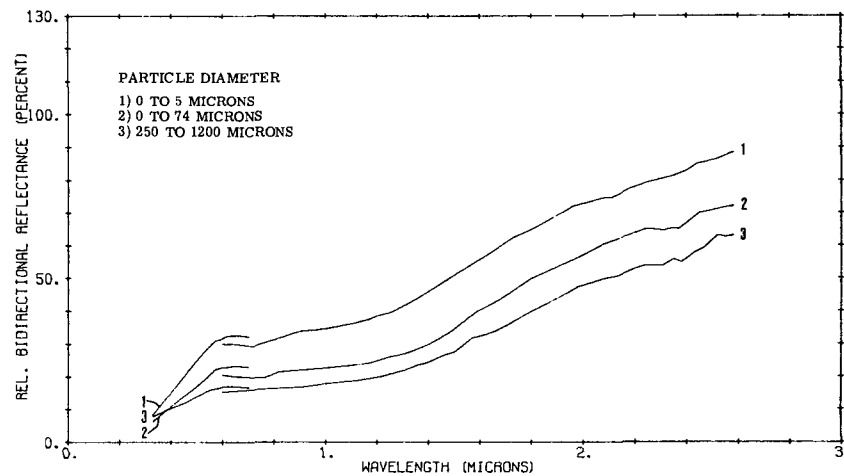
AMPHIBOLE (CLINTONVILLE, NEW YORK), VARIETY HORNBLENDE  
1) B09000 021, 2) B09000 022, 3) B09000 023, 4) B09000 024



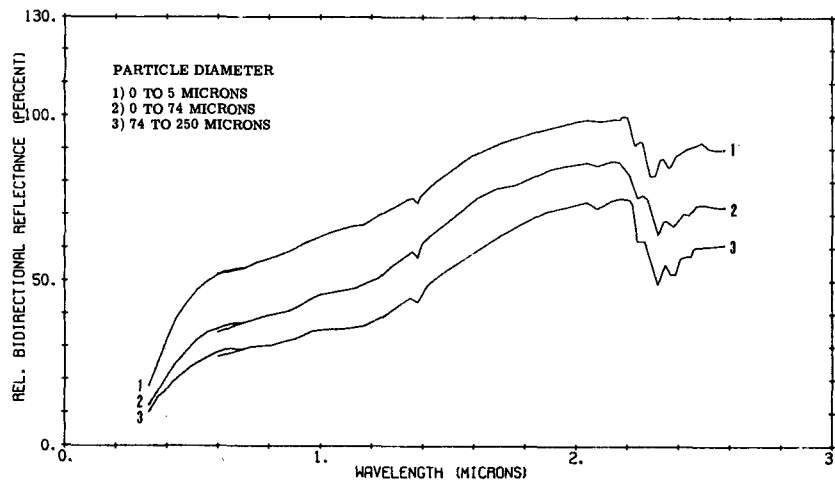
AMPHIBOLE (GORE MOUNTAIN, NEW YORK), VARIETY HORNBLENDE  
1) B09000 025, 2) B09000 026, 3) B09000 027, 4) B09000 028



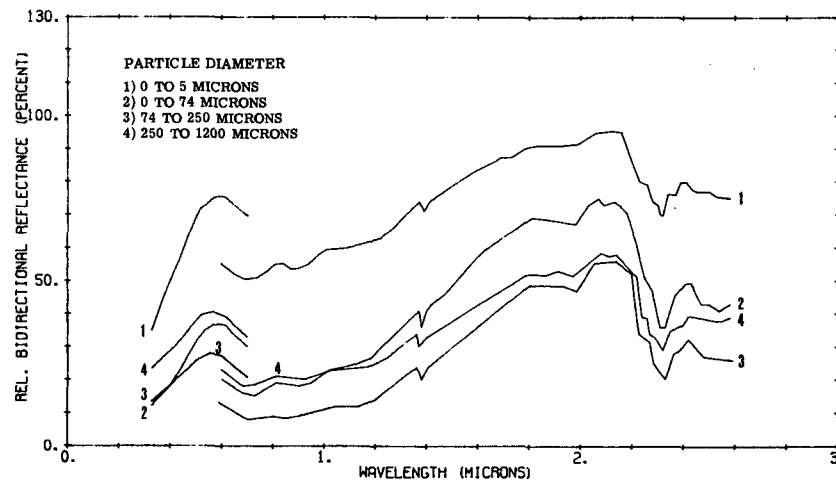
BIOTITE (BANCROFT, ONTARIO)  
1) B09000 041, 2) B09000 042, 3) B09000 043



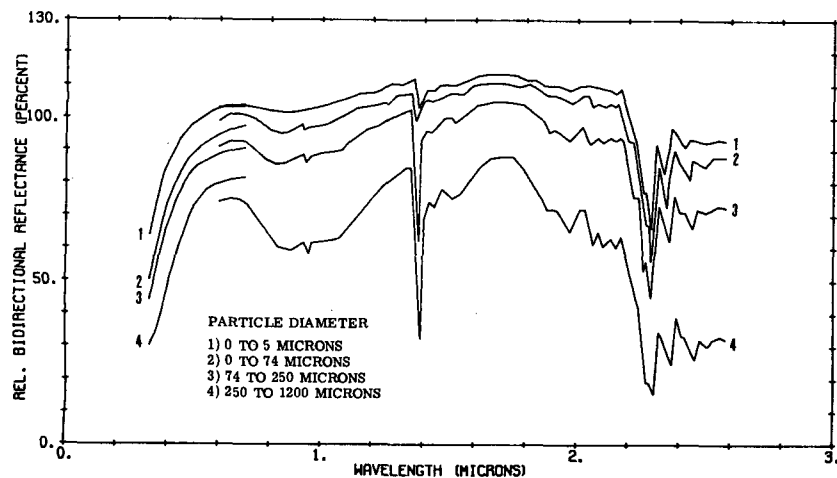
CHLORITE (COLORADO)  
1) B09000 046, 2) B09000 047, 4) B09080 048



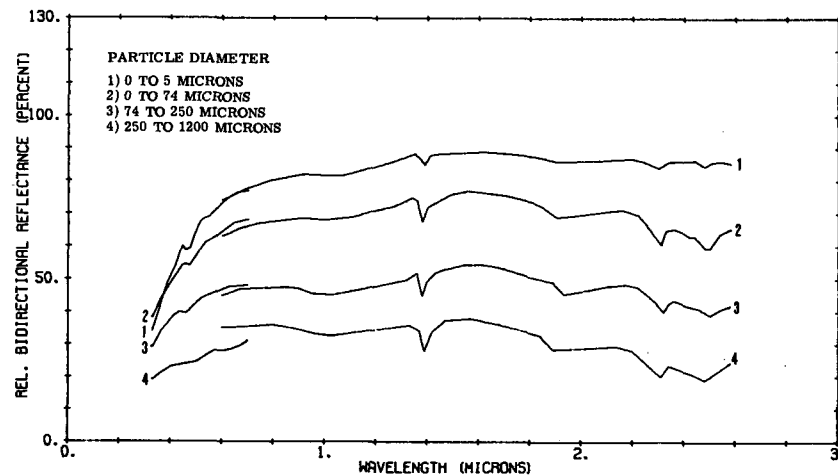
CHLORITE (CALAVERAS COUNTY, CALIFORNIA)  
1) B09000 049, 2) B09000 051, 3) B09000 052, 4) B09000 050

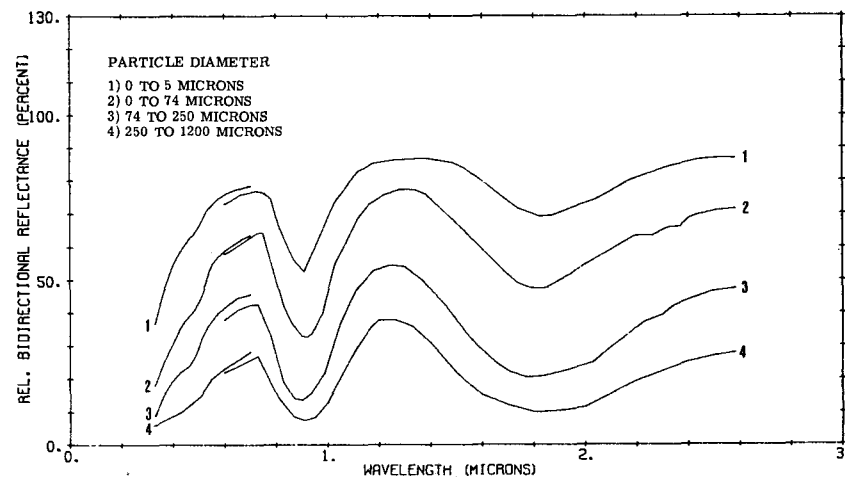
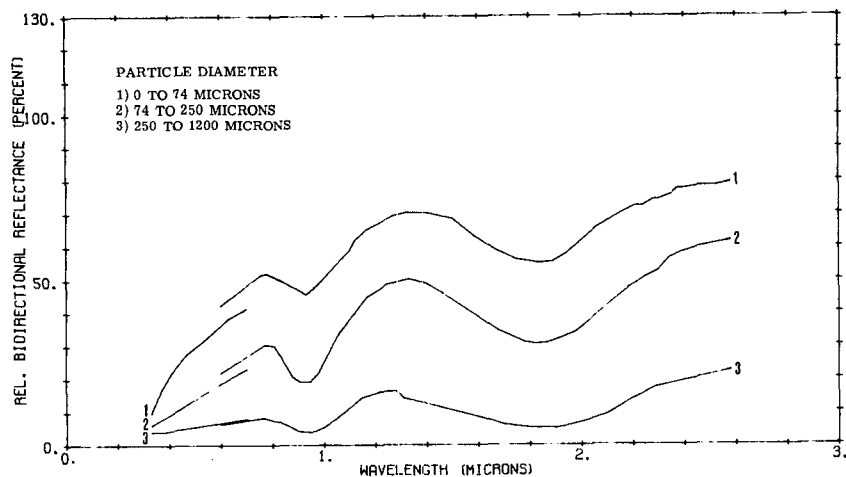
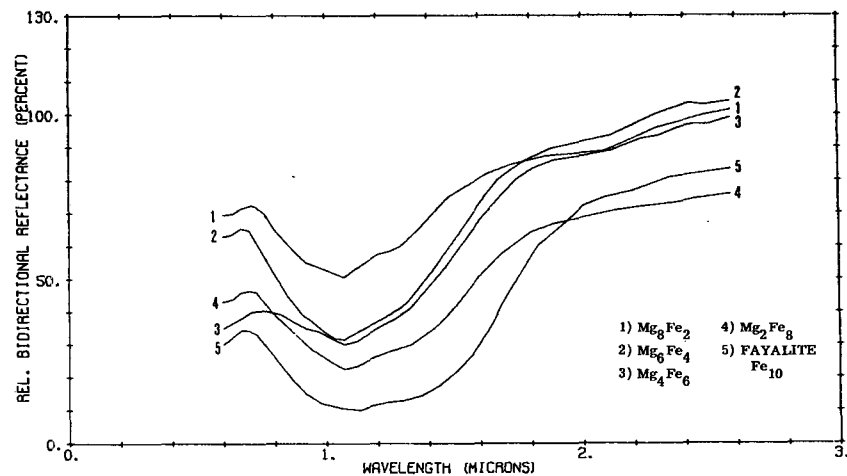
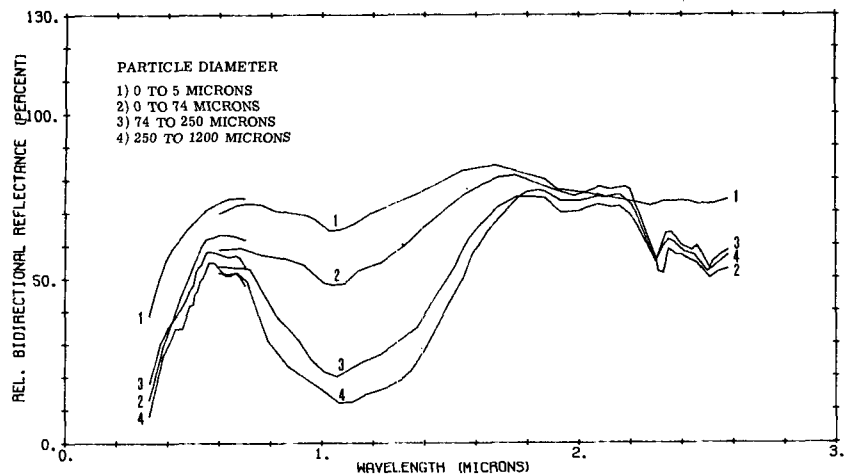


TALC (SWAIN COUNTY, NORTH CAROLINA)  
1) B09000 064, 2) B09000 065, 3) B09000 066, 4) B09000 067



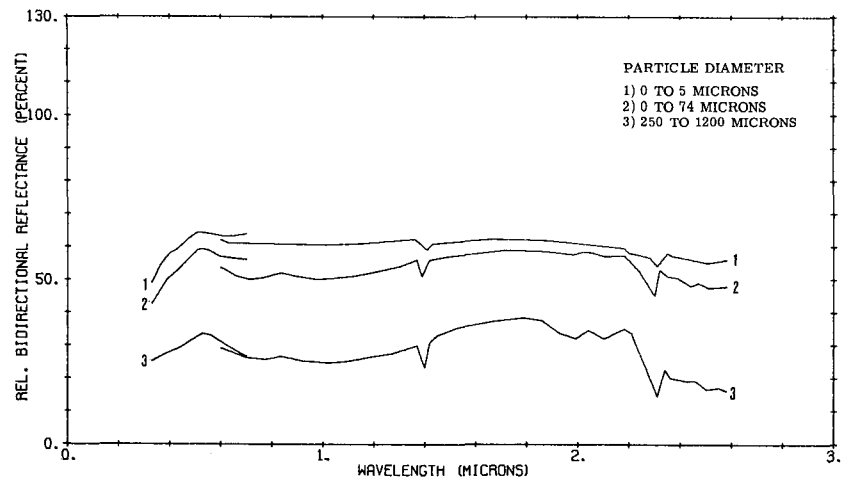
OLIVINE (CRESTMORE, CALIFORNIA) VARIETY FORSTERITE  
1) B09000 087, 2) B09000 088, 3) B09000 089, 4) B09000 090





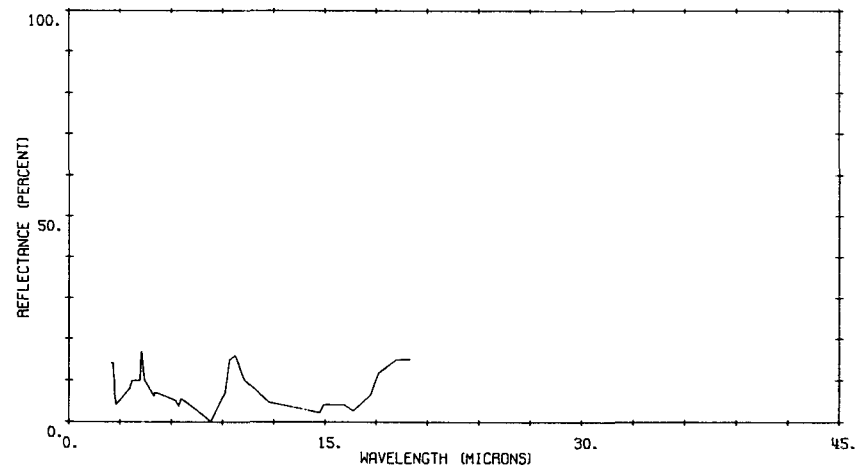


SERPENTINE (CARDIFF, MISSOURI)  
 1) B09000 153, 2) B09000 154, 3) B09000 155



B09006 019

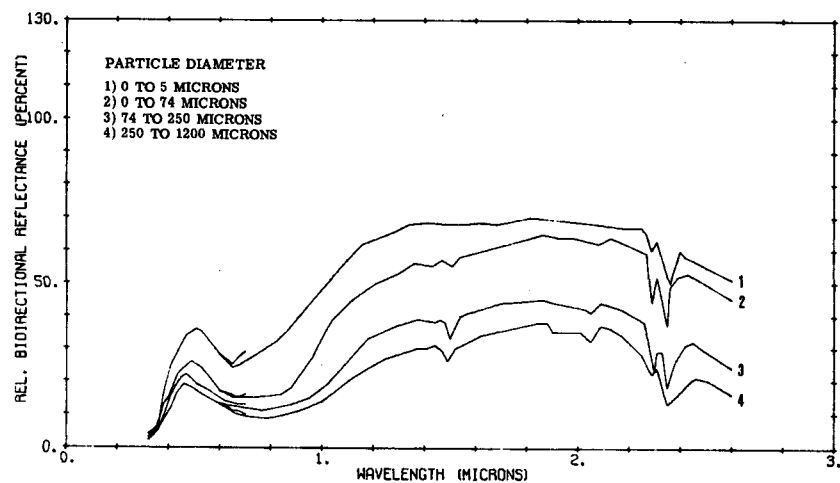
CHLORITE (BAJA CALIFORNIA, MEXICO).



123A  
CARBONATE MINERALS

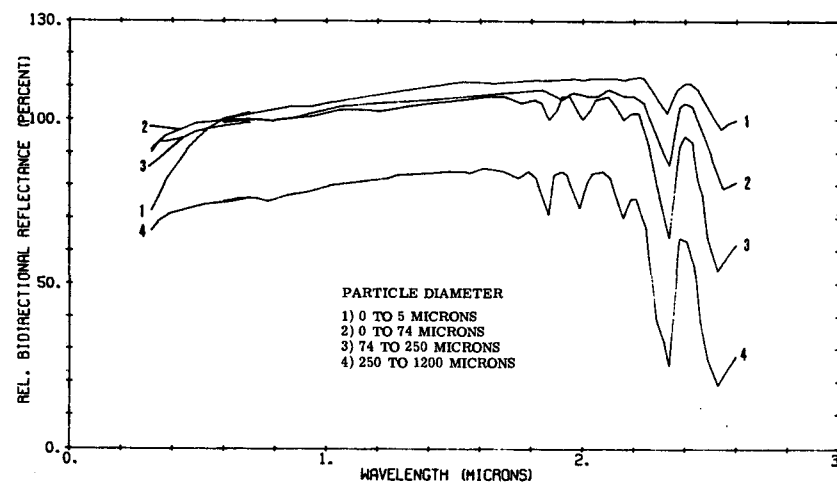
AZURITE (BISBEE, ARIZONA)

1) B09008 001, 2) B09008 002, 3) B09008 003, 4) B09008 004



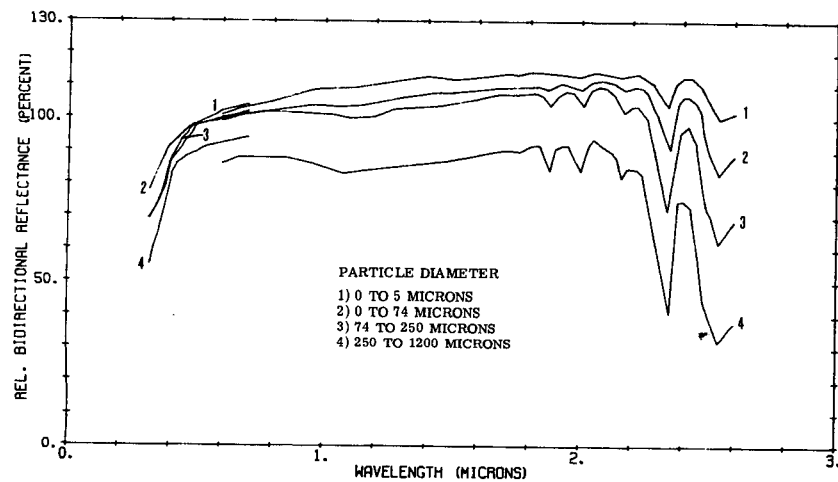
CALCITE (MEXICO)

1) B09008 005, 2) B09008 006, 3) B09008 007, 4) B09008 008



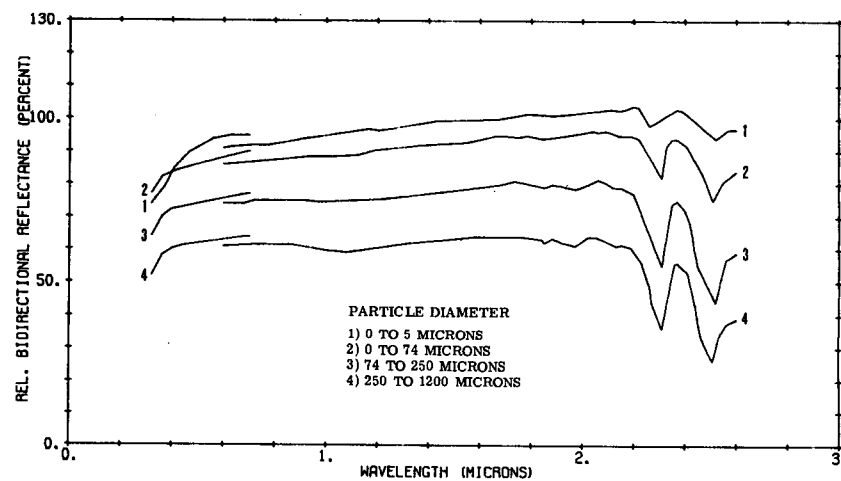
CALCITE (CHEROKEE COUNTY, KANSAS)

1) B09008 011, 2) B09008 009, 3) B09008 010, 4) B09008 012



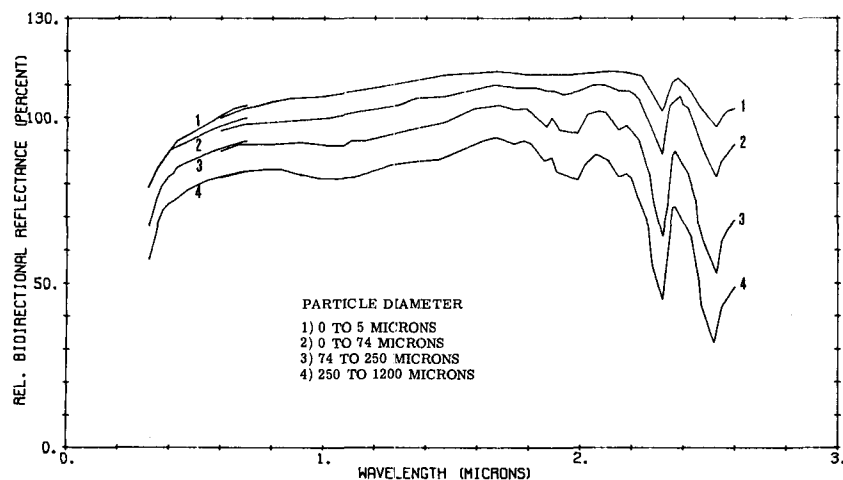
DOLOMITE (LEE, MASSACHUSETTS)

1) B09008 013, 2) B09008 014, 3) B09008 015, 4) B09008 016



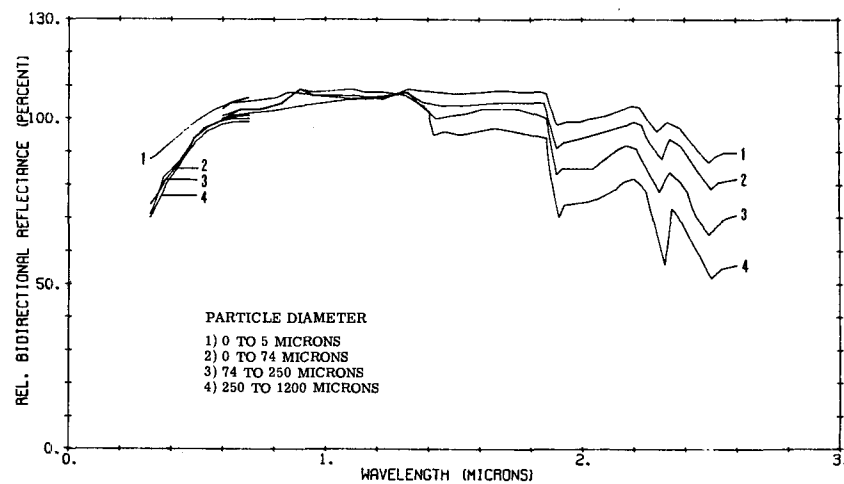
DOLomite (THORNWOOD, NEW YORK)

1) B09008 017, 2) B09008 018, 3) B09008 019, 4) B09008 020



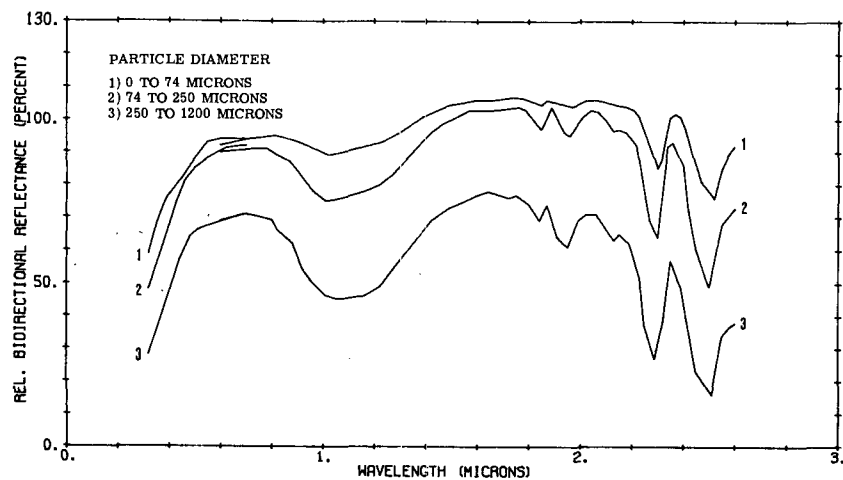
MAGNESITE (VICTORVILLE, CALIFORNIA)

1) B09008 021, 2) B09008 022, 3) B09008 023, 4) B09008 024



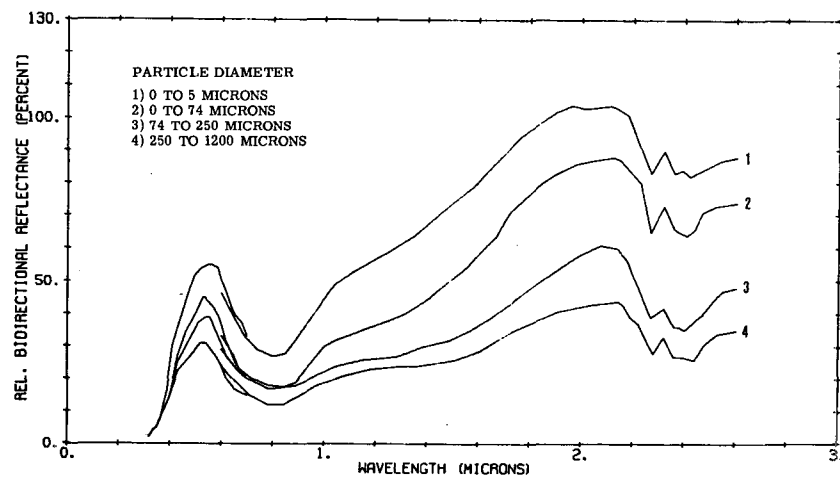
MAGNESITE (NORWAY)

1) B09008 025, 2) B09008 026, 3) B09008 027

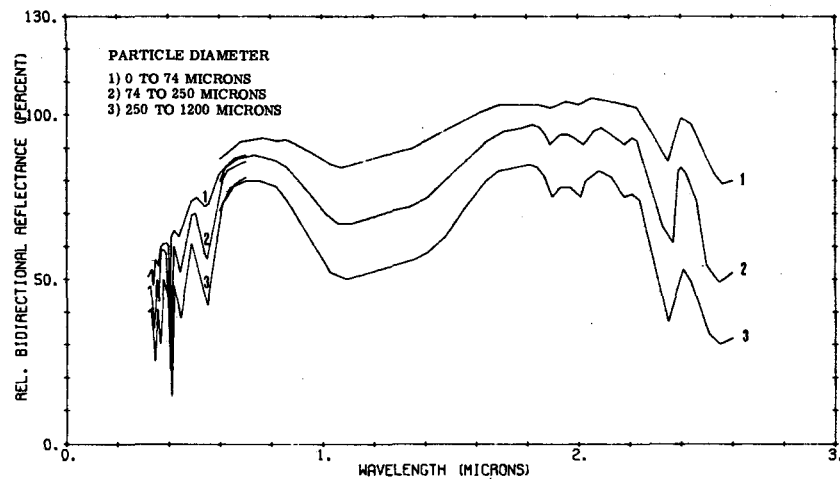


MALACHITE (BISBEE, ARIZONA)

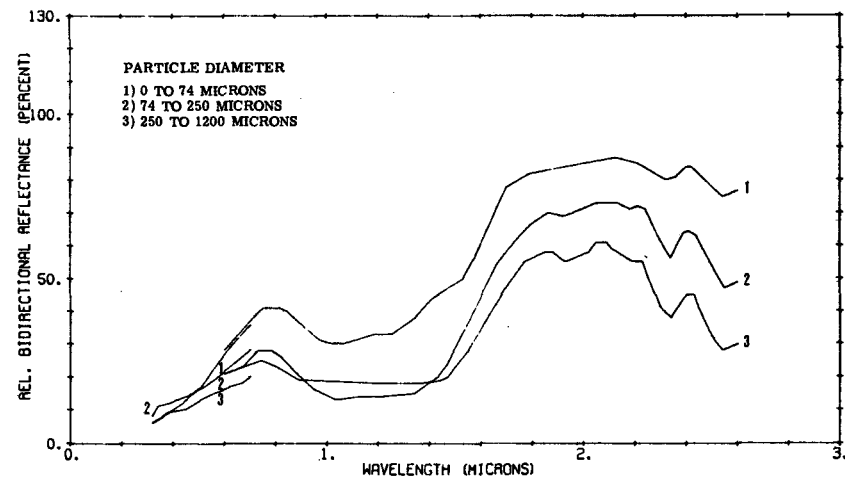
1) B09008 028, 2) B09008 029, 3) B09008 030, 4) B09008 031



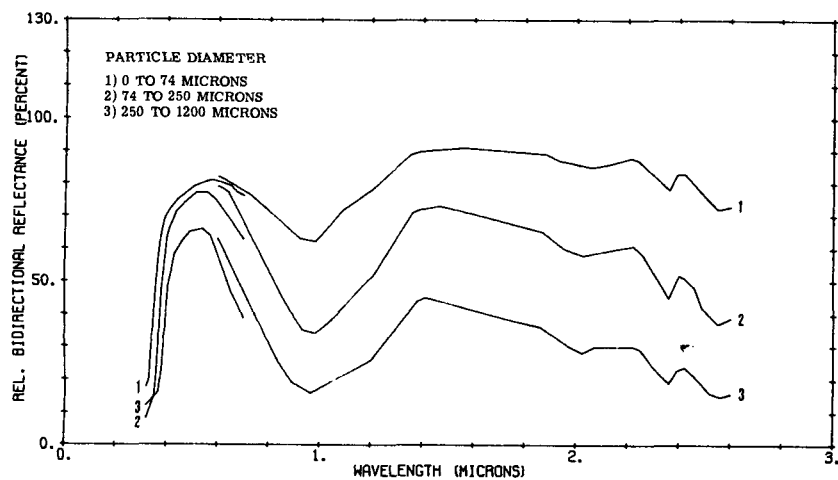
RHODOCHROSITE (CATAMARCA PROVENIENCE, ARGENTINA)  
1) B09008 032, 2) B09008 033, 3) B09008 034



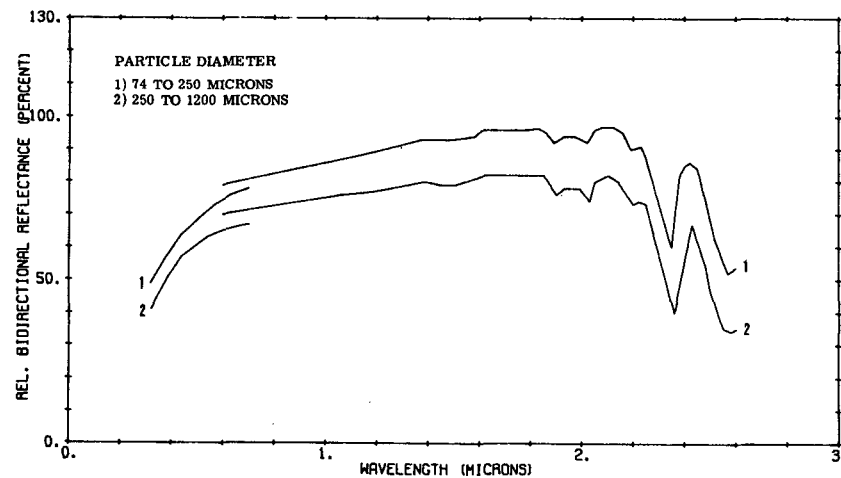
SIDERITE (ROXBURY, CONNECTICUT)  
1) B09008 035, 2) B09008 036, 3) B09008 037



SMITHSONITE (KELLY, NEW MEXICO)  
1) B09008 038, 2) B09008 039, 3) B09008 040

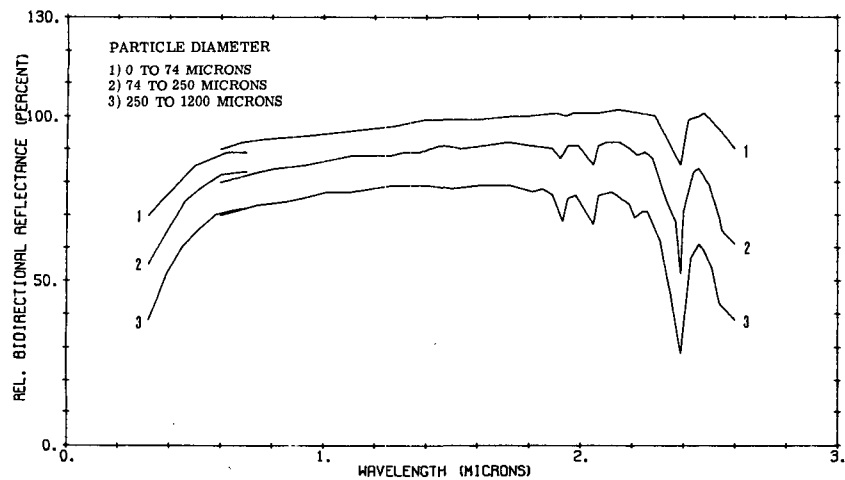


STRONTIANITE (HAMM, WESTPHALIA)  
1) B09008 041, 2) B09008 042



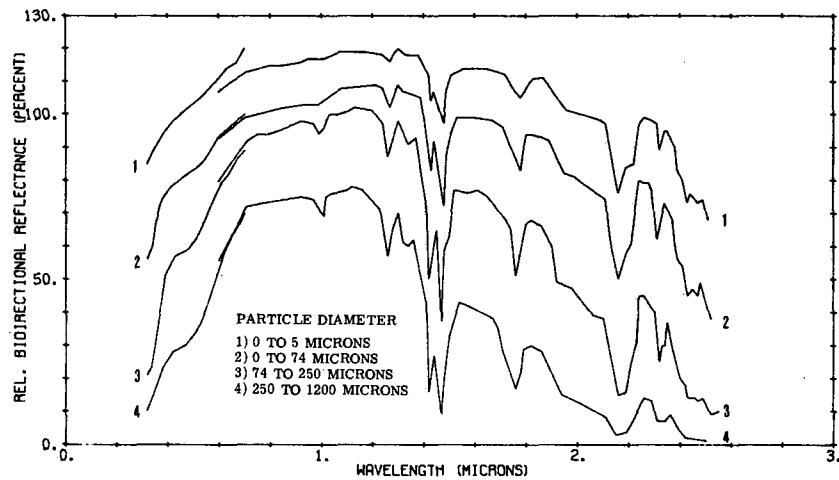
WITHERITE (ENGLAND)

1) 809008 043, 2) 809008 044, 3) 809008 045

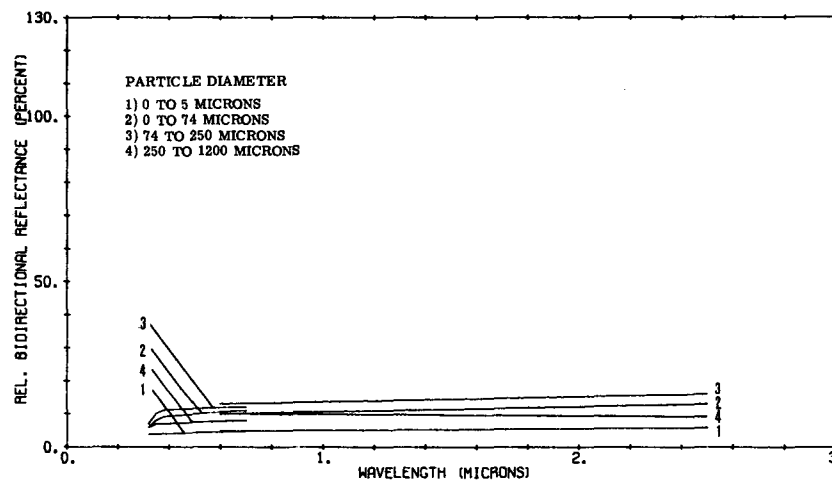


123B  
SULPHUR, SULFATE,  
AND SULFIDE MINERALS

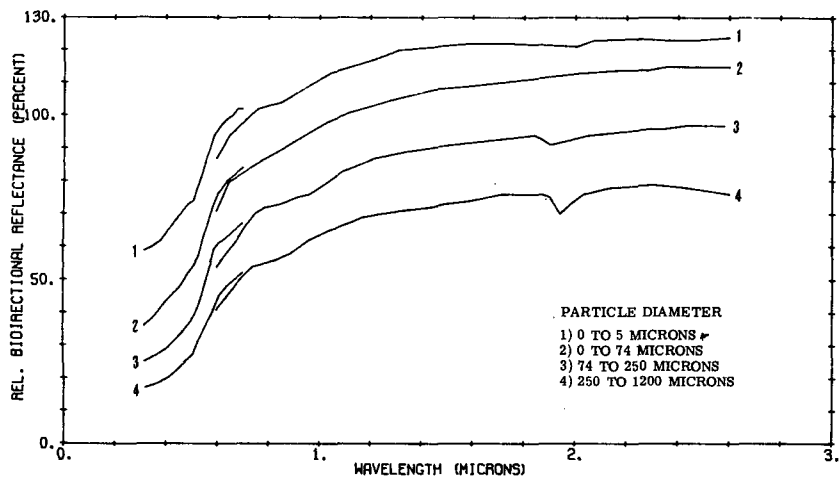
ALUNITE (UTAH)  
1) B09009 001, 2) B09009 002, 3) B09009 003, 4) B09009 004



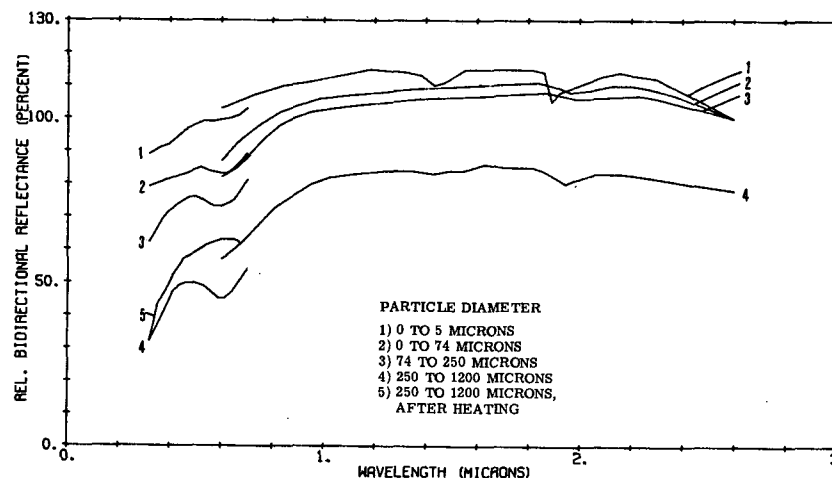
ARSENOPYRITE (GOLD HILL, UTAH)  
1) B09009 005, 2) B09009 006, 3) B09009 007, 4) B09009 008



BARITE (CUSTER, COLORADO)  
1) B09009 009, 2) B09009 010, 3) B09009 011, 4) B09009 012



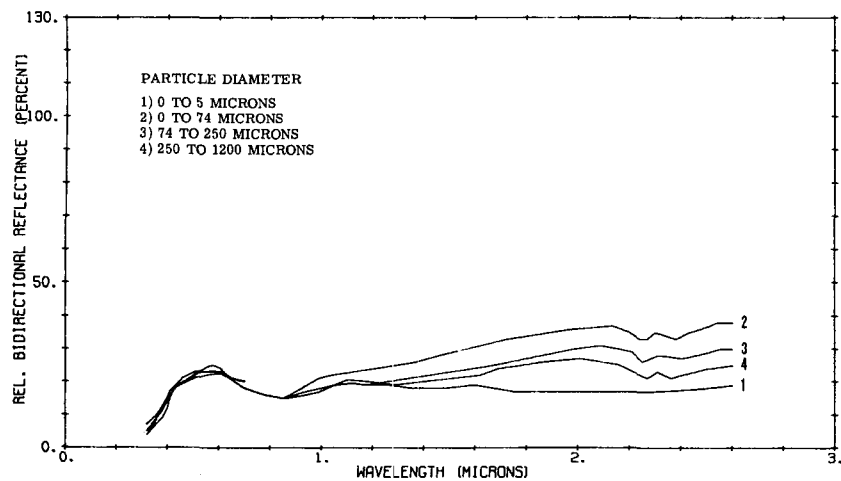
CELESTITE (MEXICO)  
1) B09009 013, 2) B09009 014, 3) B09009 015, 4) B09009 016, 5) B09009 017





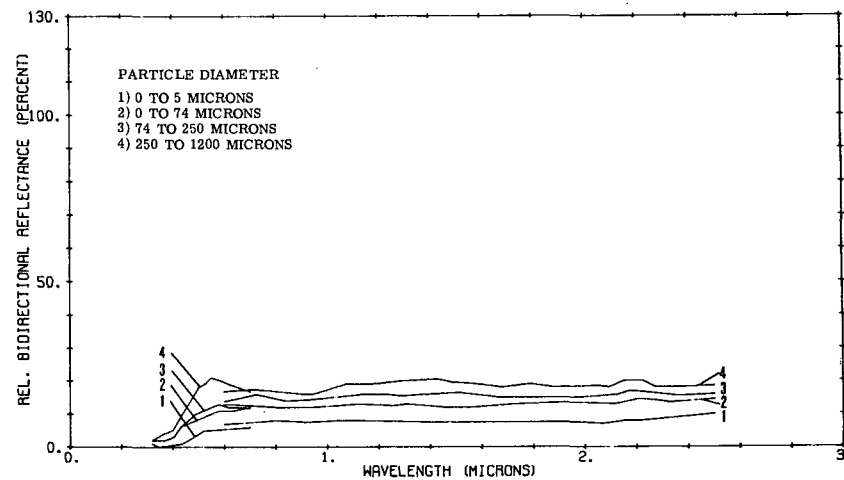
# CHALCOCITE (BUTTE, MONTANA)

1) B09009 018, 2) B09009 019, 3) B09009 020, 4) B09009 021



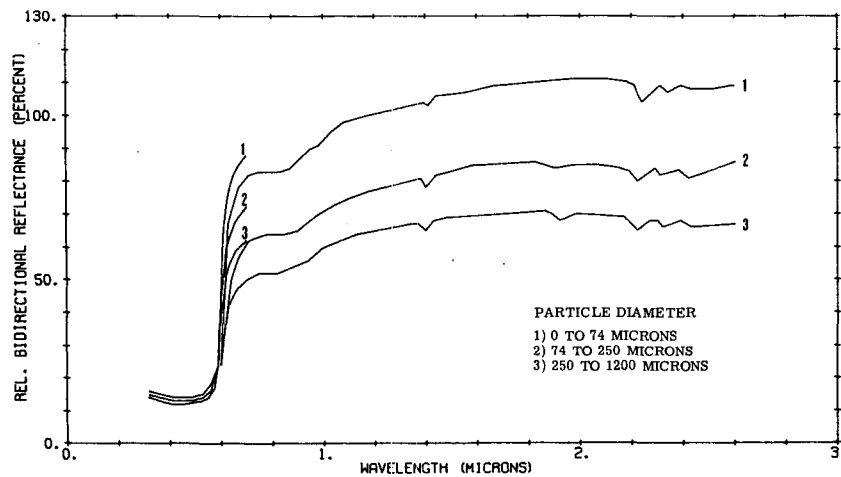
# CHALCOPYRITE (QUEBEC)

1) B09009 022, 2) B09009 023, 3) B09009 024, 4) B09009 025



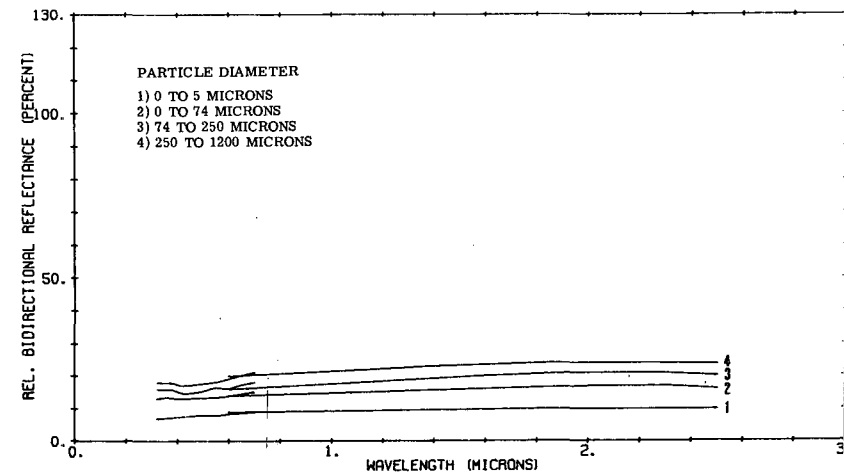
# CINNABAR (MANHATTAN, NEVADA)

1) B09009 026, 2) B09009 027, 3) B09009 028



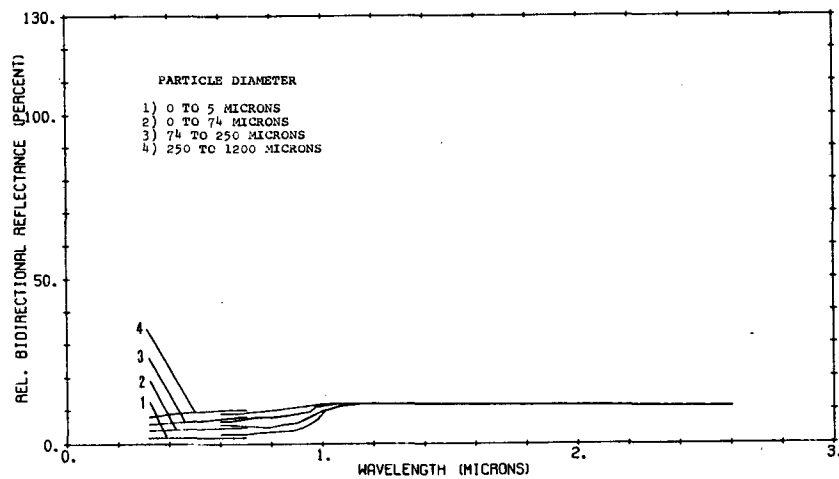
# COBALTITE (ELLIOT LAKE, ONTARIO)

1) B09009 029, 2) B09009 030, 3) B09009 031, 4) B09009 032



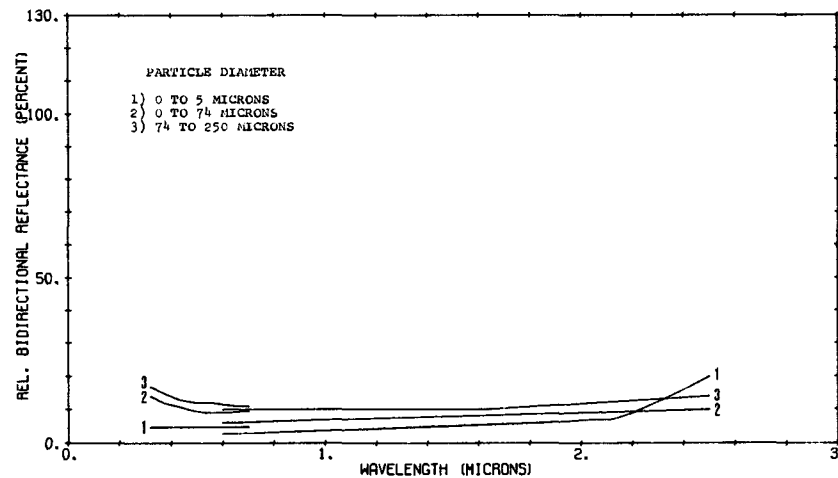
# ENARGITE (PERU)

1) B09009 033, 2) B09009 034, 3) B09009 035, 4) B09009 036



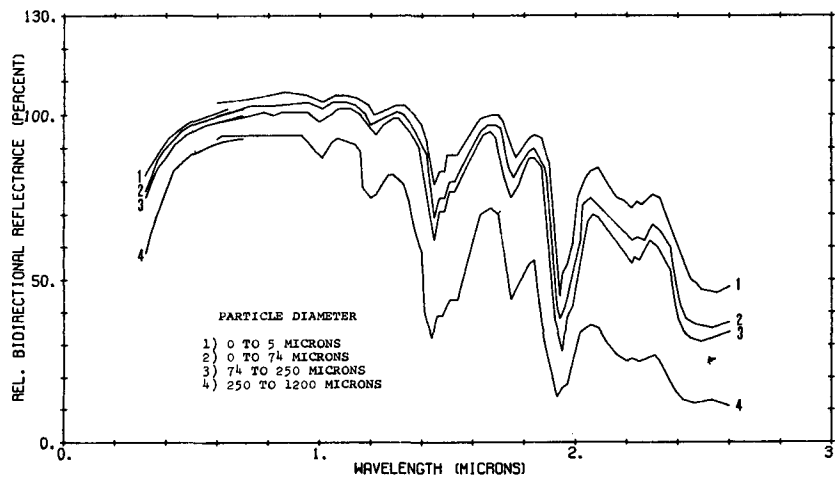
# GALENA (GALENA, KANSAS)

1) B09009 037, 2) B09009 038, 3) B09009 039



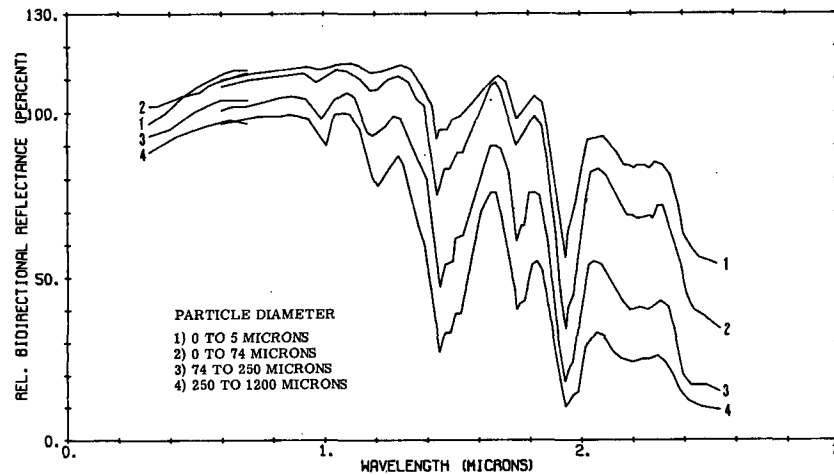
# GYPSUM (POMATA, ITALY)

1) B09009 040, 2) B09009 041, 3) B09009 042, 4) B09009 043



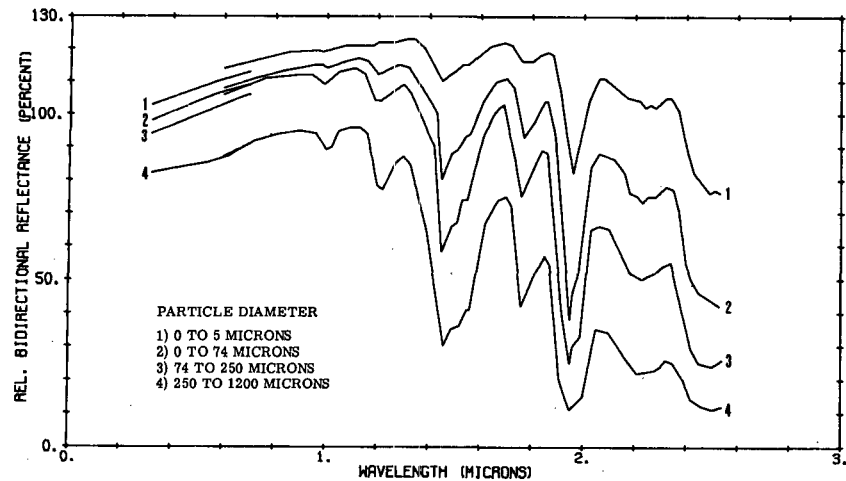
# GYPSUM (WASHINGTON COUNTY, UTAH)

1) B09009 044, 2) B09009 045, 3) B09009 046, 4) B09009 047



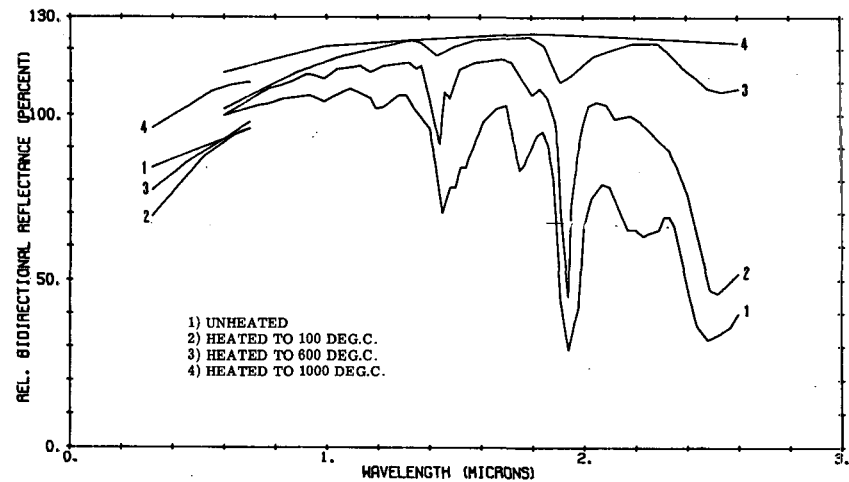
GYPSUM (BALMAT, NEW YORK)

1) B09009 048, 2) B09009 049, 3) B09009 050, 4) B09009 051



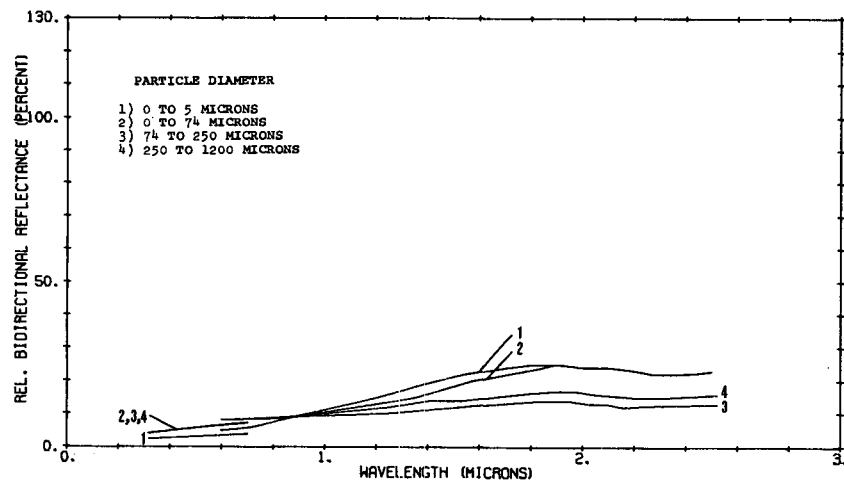
GYPSUM (BALMAT, NEW YORK), PARTICLE DIAMETER--74 TO 250 MICRONS

1) B09009 052, 2) B09009 053, 3) B09009 054, 4) B09009 055



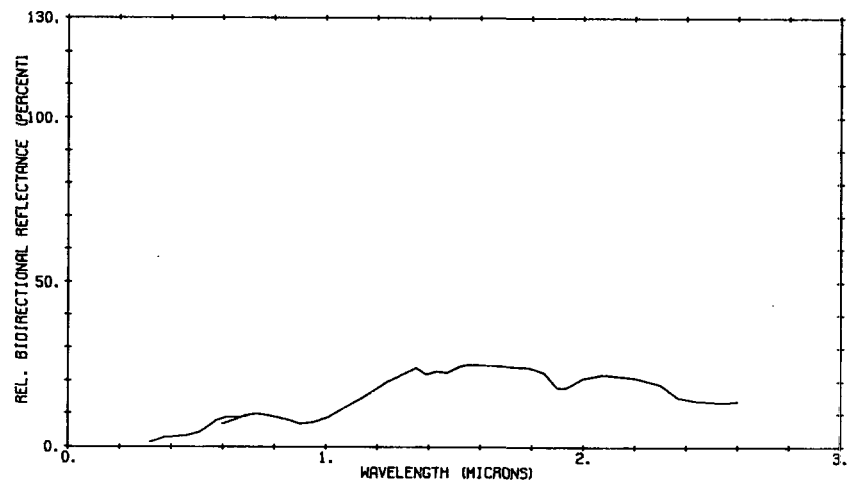
JAMESONITE (BOLIVIA)

1) B09009 056, 2) B09009 057, 3) B09009 058, 4) B09009 059

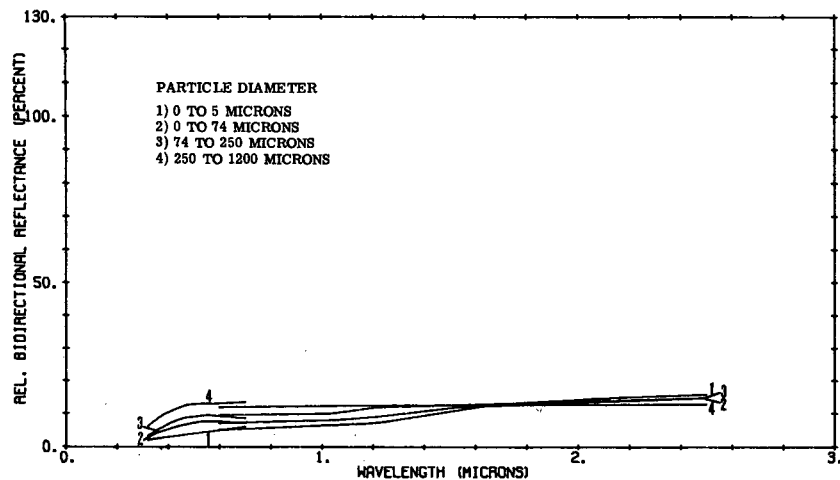


B09009 060

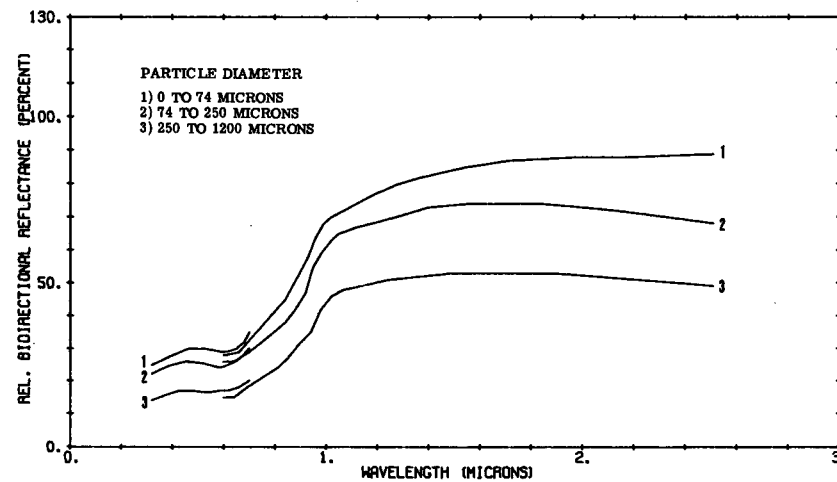
JAROSITE (WARNER MINE, NEVADA)



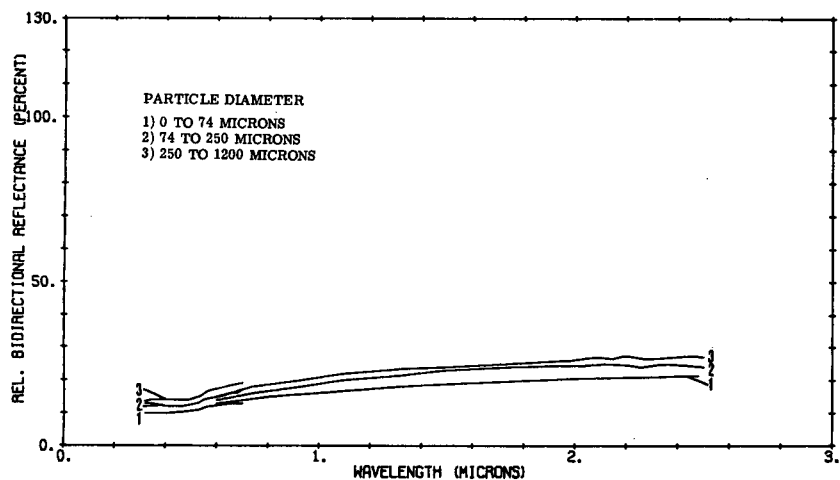
MARCASITE (OTTAWA COUNTY, OKLAHOMA)  
1) B09009 061, 2) B09009 062, 3) B09009 063, 4) B09009 064



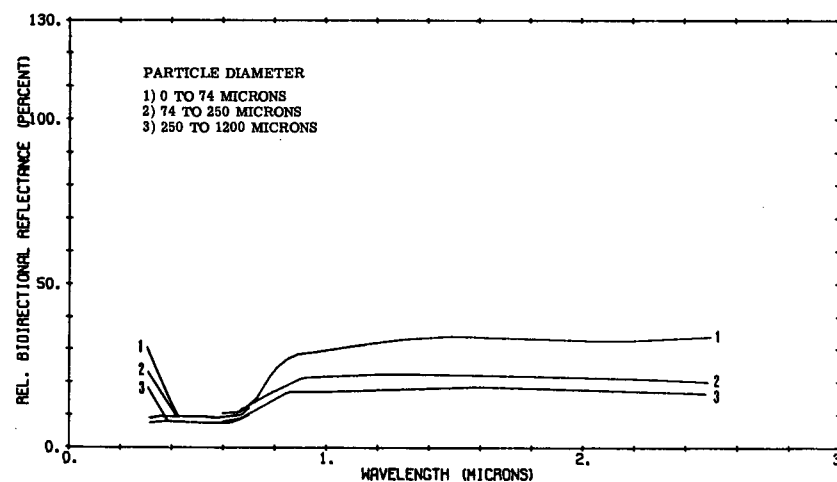
MOLYBDENITE (SALT LAKE CITY, UTAH)  
1) B09009 065, 2) B09009 066, 3) B09009 067

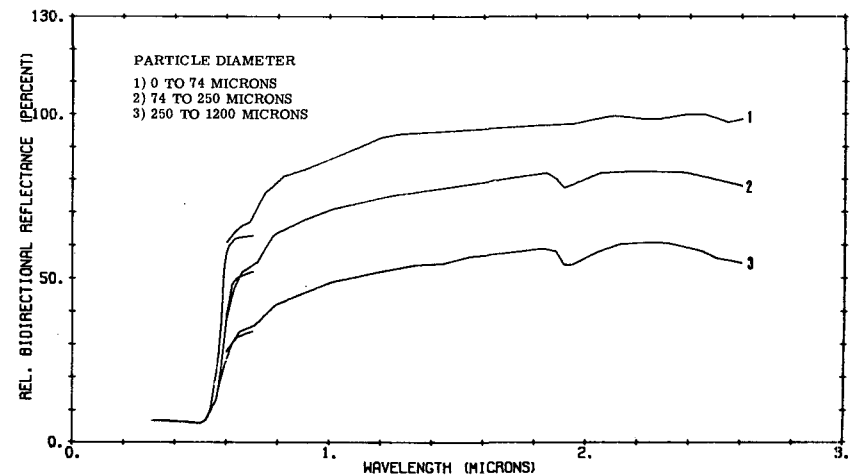
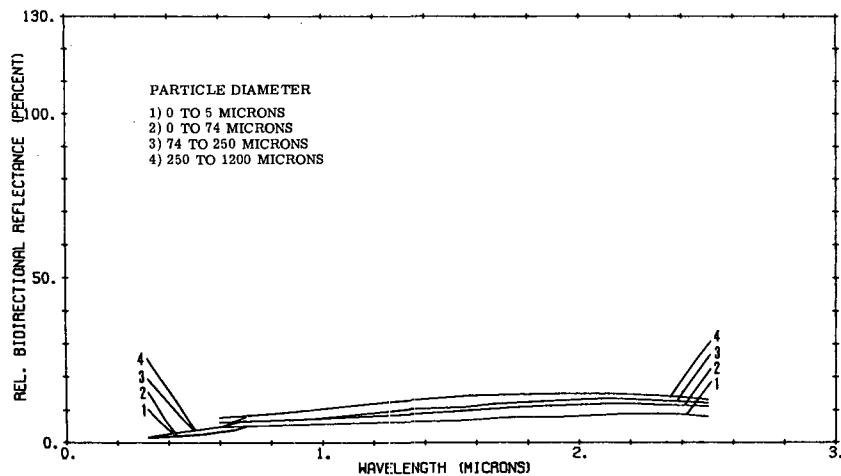
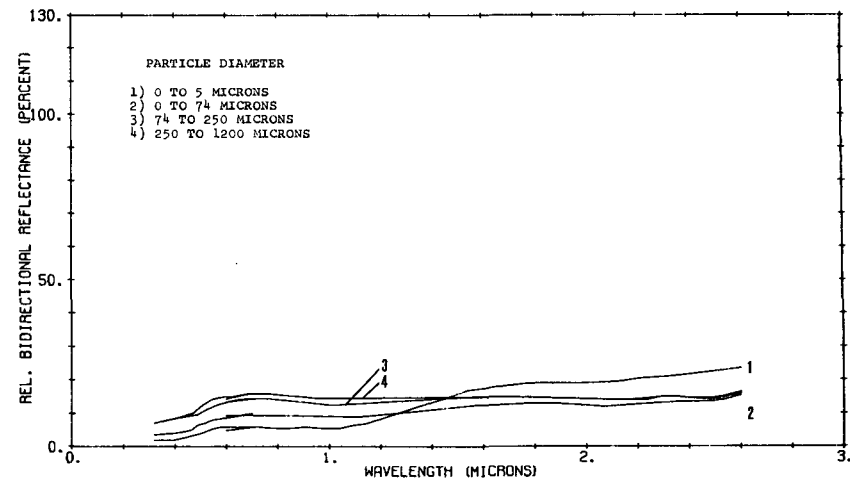
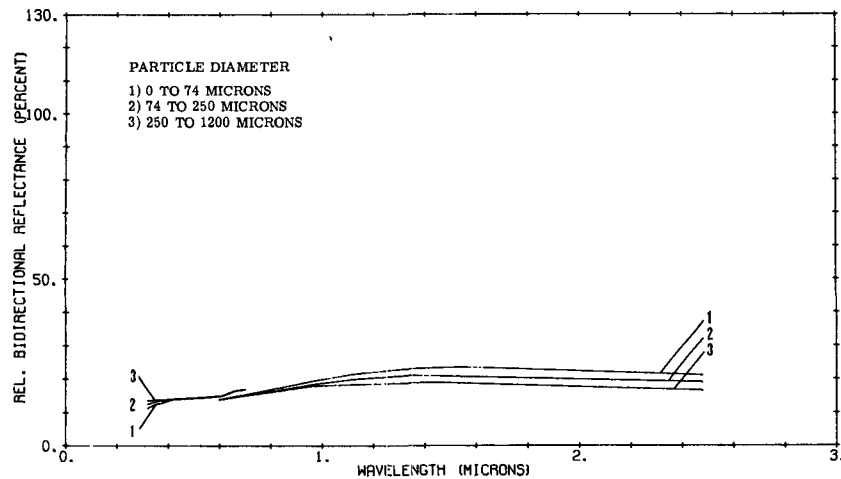


NICCOLITE (COBALT, ONTARIO)  
1) B09009 068, 2) B09009 069, 3) B09009 070

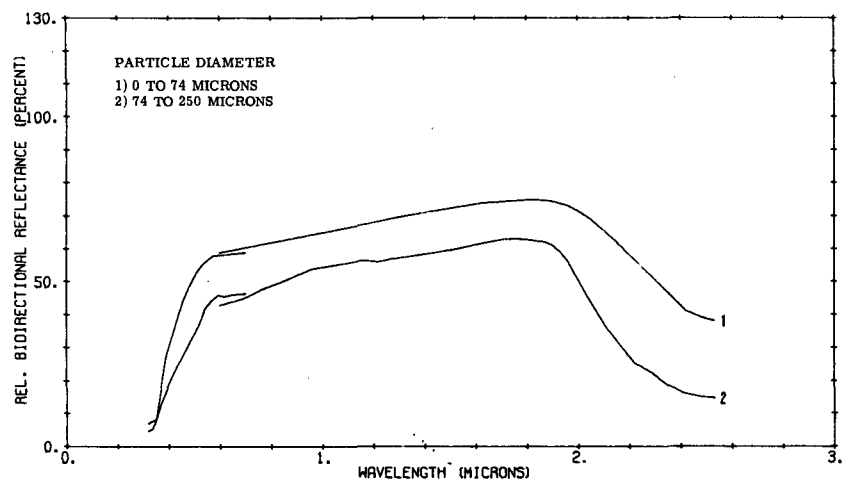


PROUSTITE (SUMMIT COUNTY, COLORADO)  
1) B09009 071, 2) B09009 072, 3) B09009 073

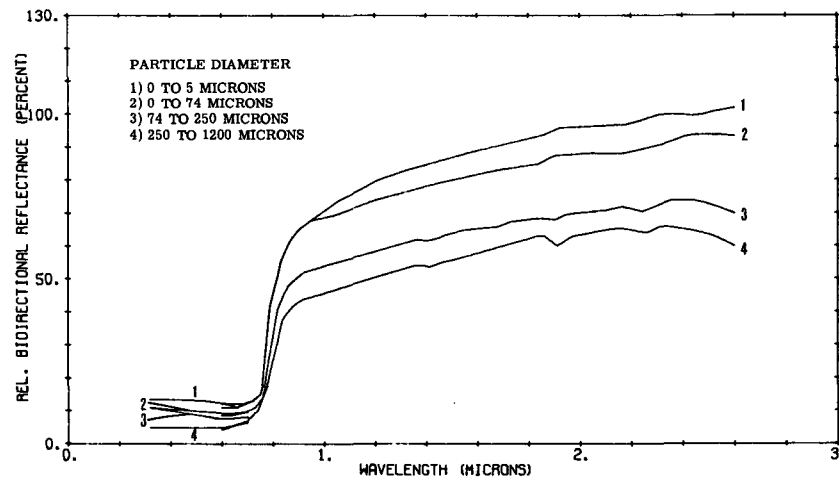




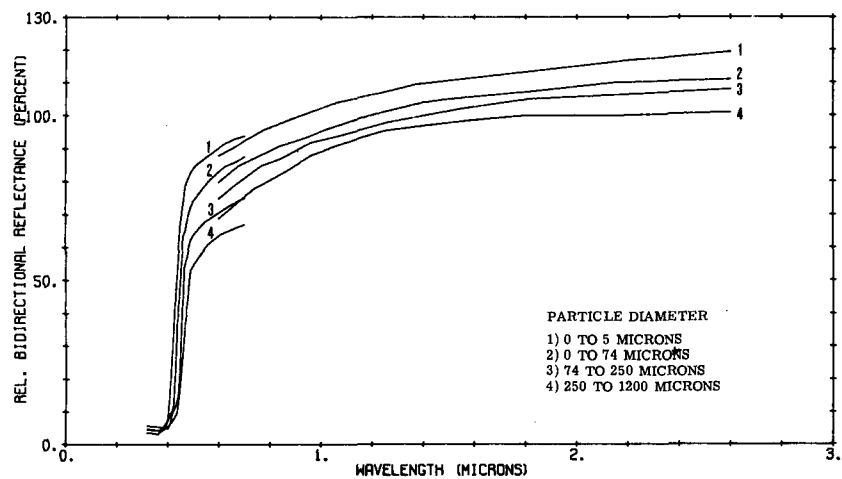
SPHALERITE (SUMMIT COUNTY, COLORADO)  
1) B09009 088, 2) B09009 089



STIBNITE (MEXICO)  
1) B09009 090, 2) B09009 091, 3) B09009 092, 4) B09009 093

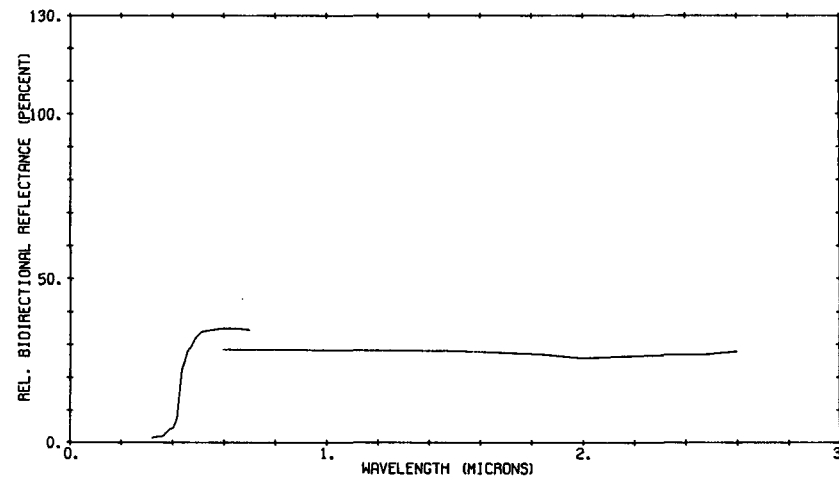


SULPHUR (WINNEMUCCA, NEVADA)  
1) B09009 094, 2) B09009 095, 3) B09009 096, 4) B09009 097



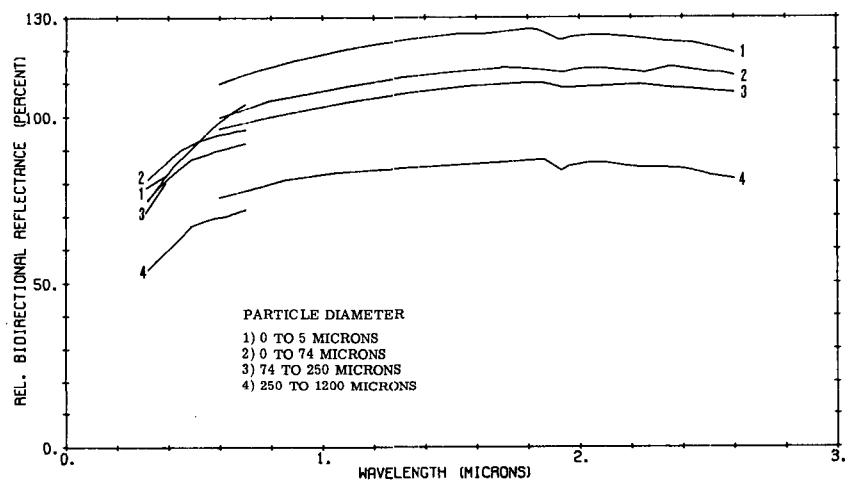
B09009 098

SUBLIMATE ON VOLCANIC ROCK (ICELAND--ISLAND OF SURTSEY)



THENARDITE (CAMPVERDE, CALIFORNIA)

1) B09009 099, 2) B09009 100, 3) B09009 101, 4) B09009 102



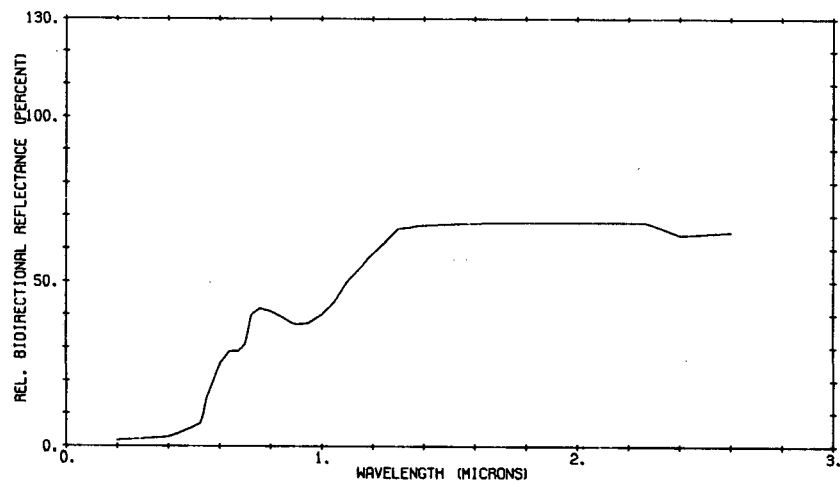
128/881

123F  
OXIDES AND HYDROXIDES



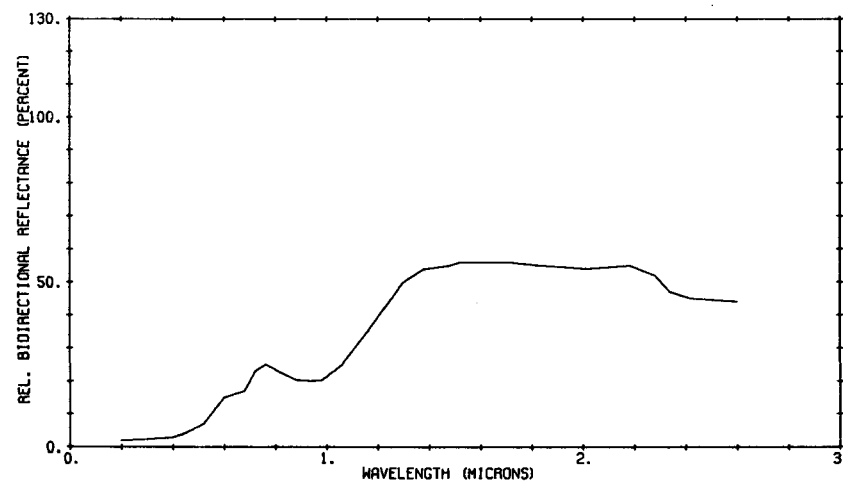
B09004 001

LIMONITE, POLISHED.



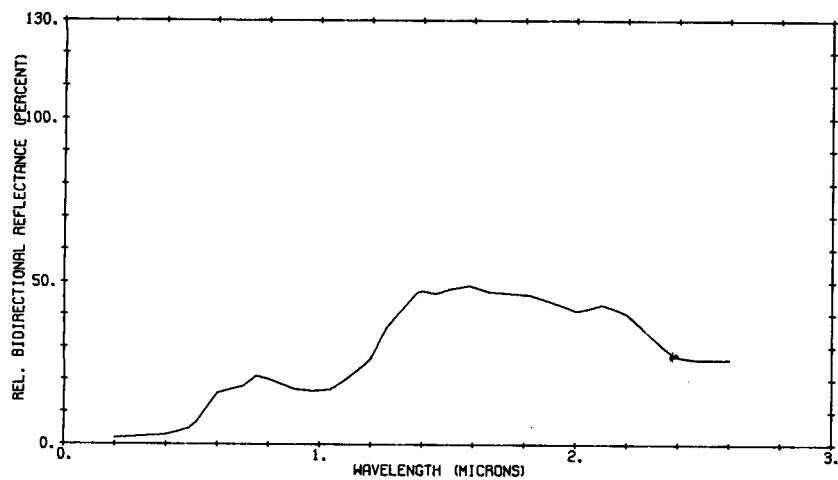
B09004 002

LIMONITE, POLISHED.



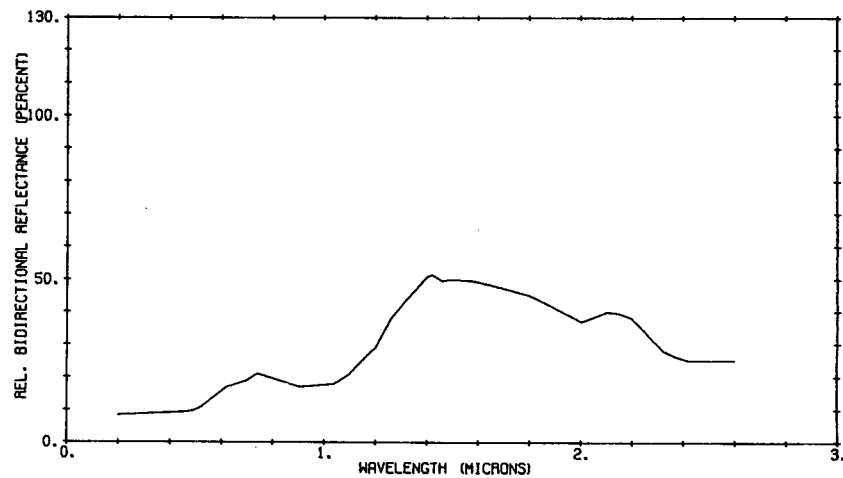
081  
B09004 003

LIMONITE, POLISHED.



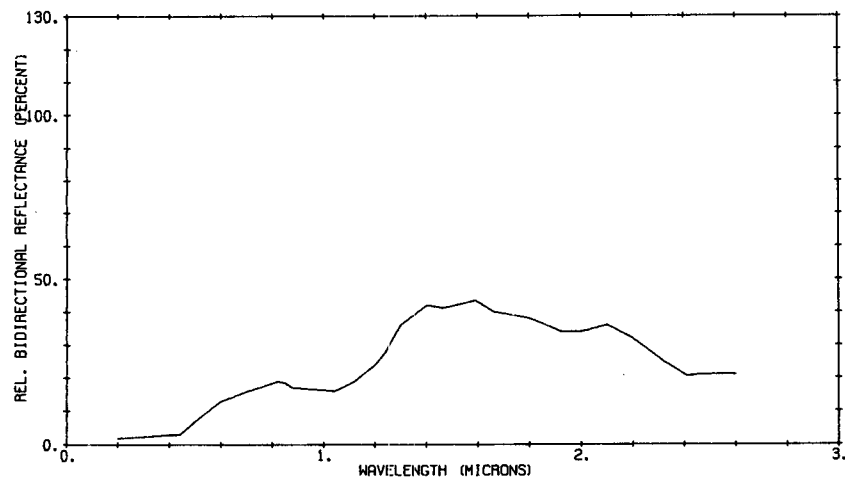
B09004 004

LIMONITE, SAWED PLATE.



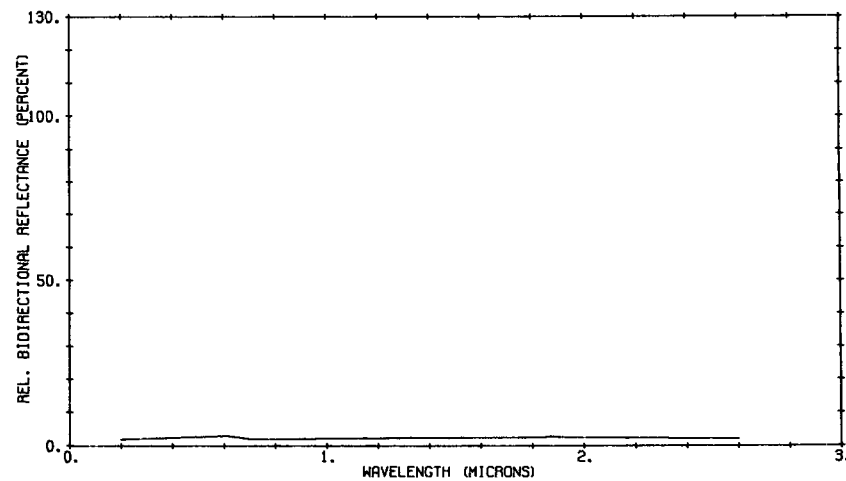
B09004 005

LIMONITE, SAWED PLATE.



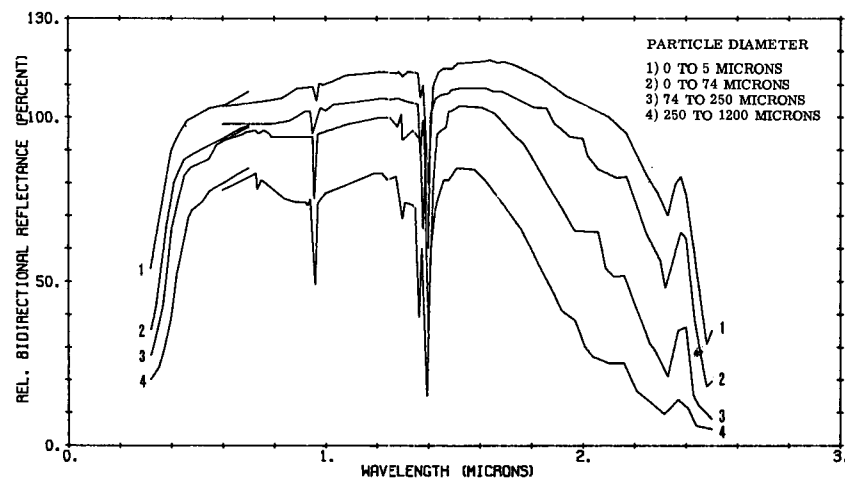
B09004 006

LIMONITE, POORLY POLISHED.



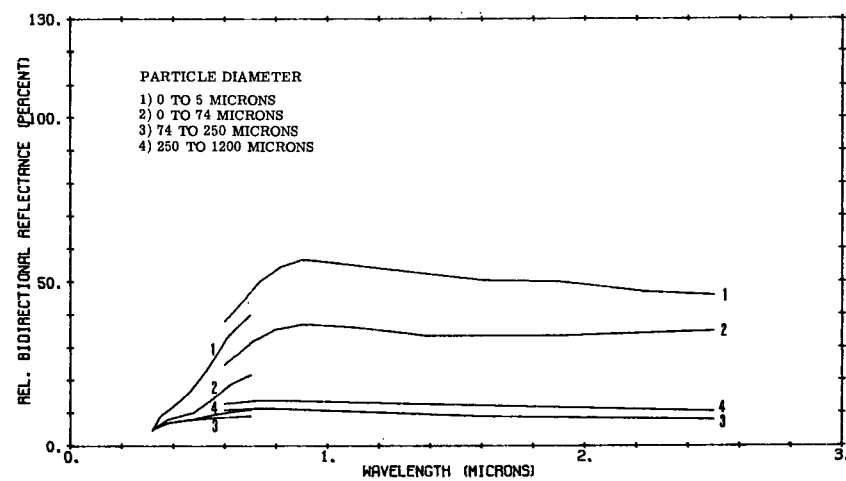
BRUCITE (LODI, NEVADA)

1) B09005 001, 2) B09005 002, 3) B09005 003, 4) B09005 004



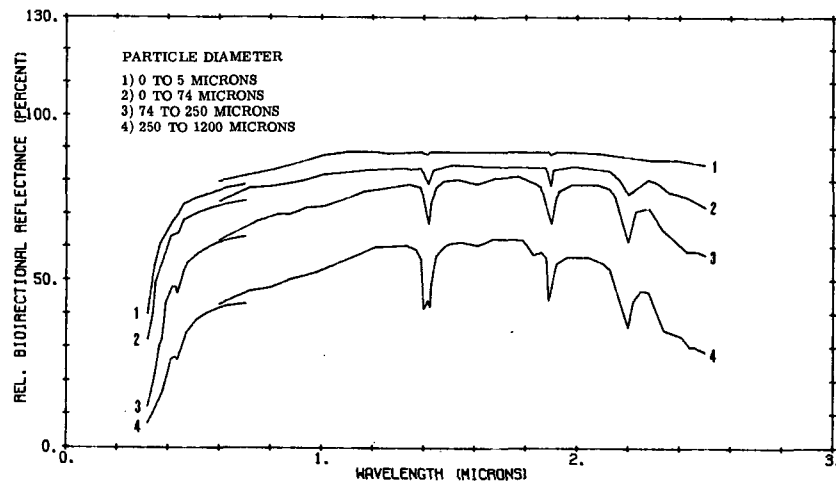
CASSITERITE (NIGERIA)

1) B09005 005, 2) B09005 006, 3) B09005 008, 4) B09005 007



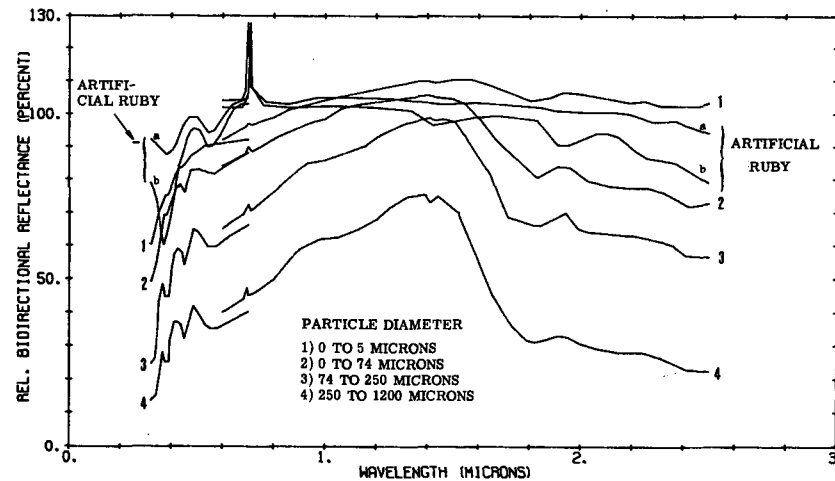
CHRYSOBERYL (SOUTH DAKOTA)

1) B09005 009, 2) B09005 010, B09005 011, 4) B09005 012



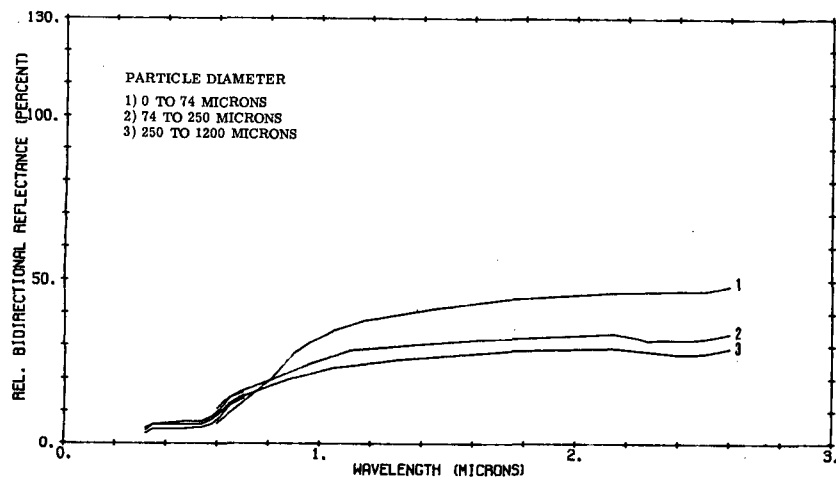
CORUNDUM (TRANSVAAL, AFRICA)

1) B09005 015, 2) B09005 016, 3) B09005 017, 4) B09005 018  
a) B09005 013, b) B09005 014



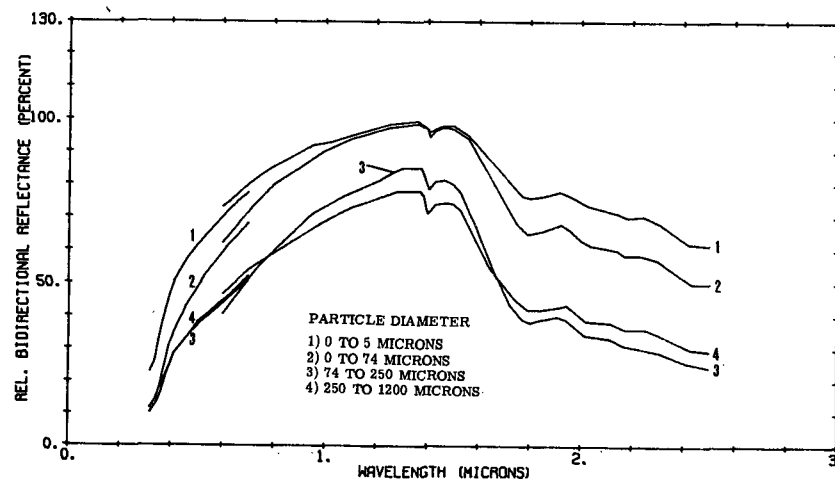
CUPRITE (BUTTE, MONTANA)

1) B09005 021, 2) B09005 019, 3) B09005 020



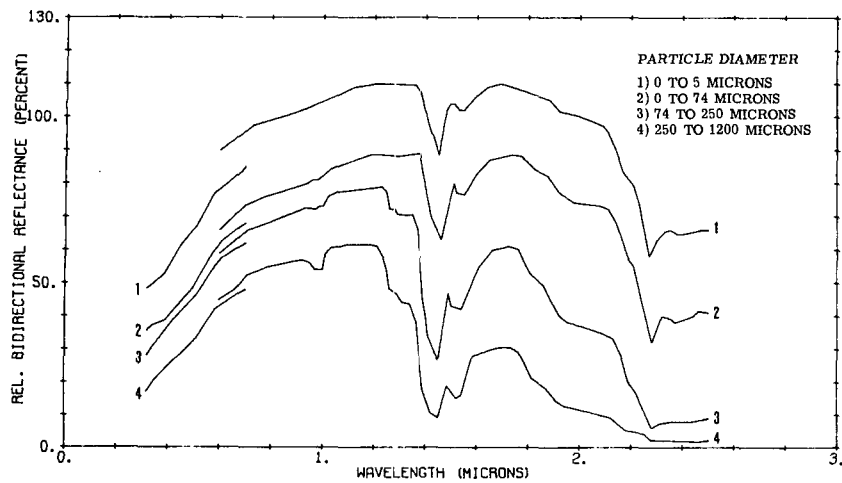
DIASPORE (ROSEBUD, MISSOURI)

1) B09005 022, 2) B09005 023, 3) B09005 024, 4) B09005 025



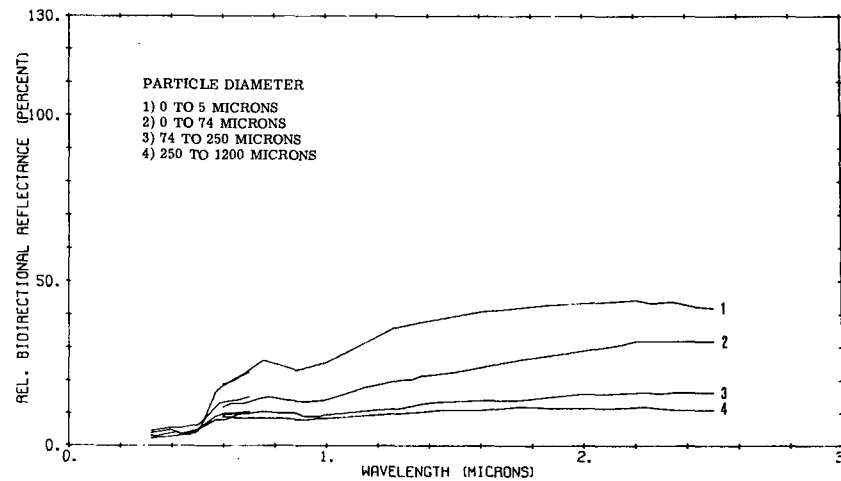
GIBBSITE (BRAZIL)

1) B09005 026, 2) B09005 027, 3) B09005 028, 4) B09005 029



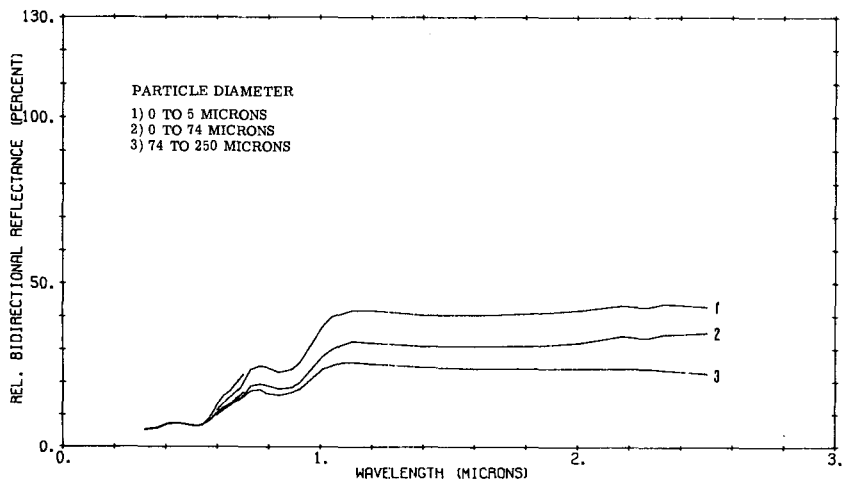
GOETHITE (BIWABIK, MINNESOTA)

1) B09005 030, 2) B09005 031, 3) B09005 032, 4) B09000 033



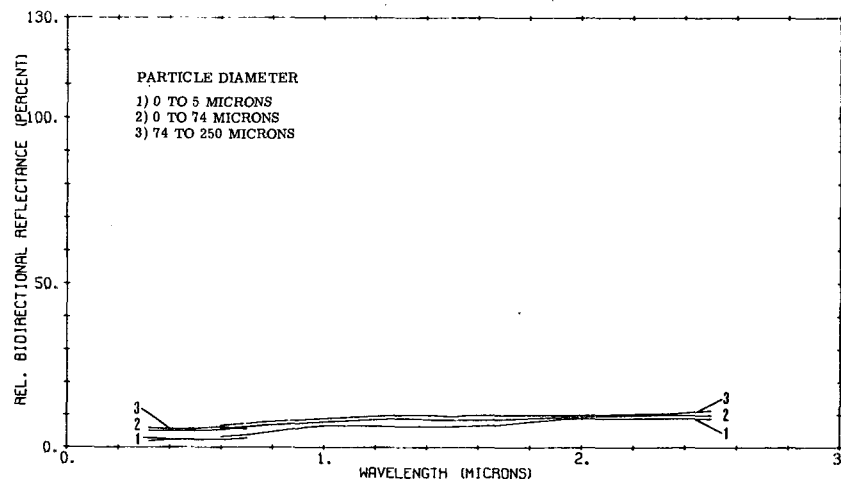
HEMATITE (IRONTOWN, MINNESOTA)

1) B09005 034, 2) B09005 035, 3) B09005 036

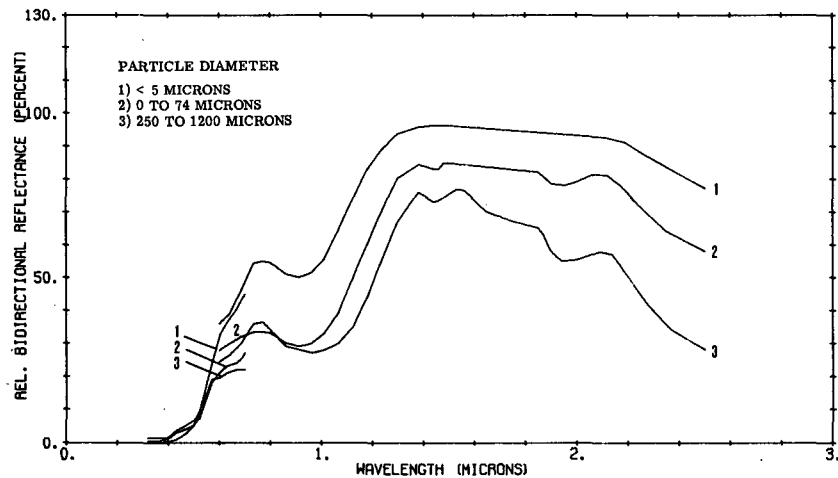


ILMENITE (NORWAY)

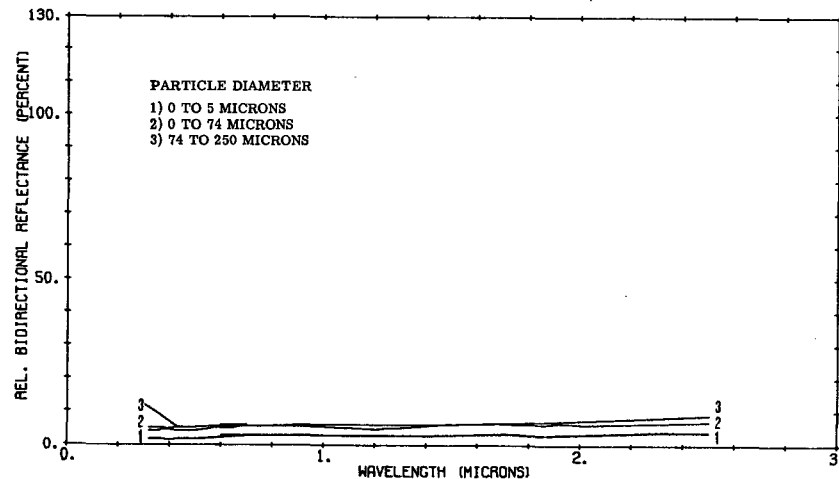
1) B09005 037, 2) B09005 038, 3) B09005 039



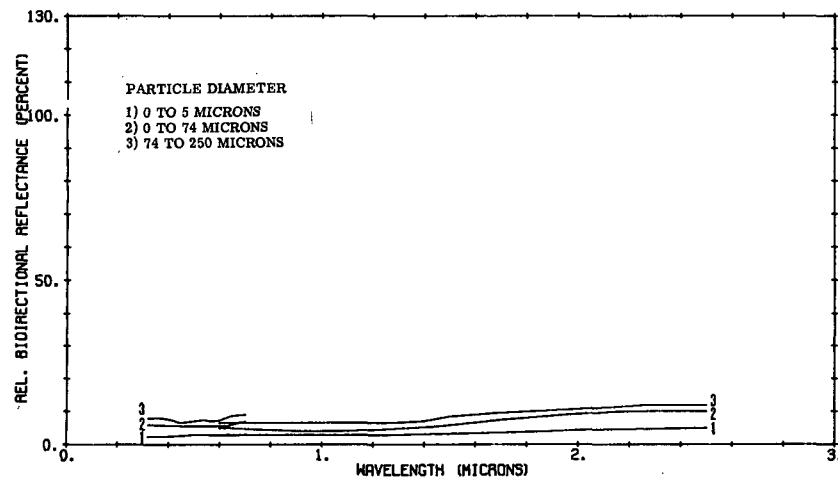
LIMONITE (TUSCALOOSA COUNTY, ALABAMA)  
1) B09005 040, 2) B09005 041, 3) B09005 042



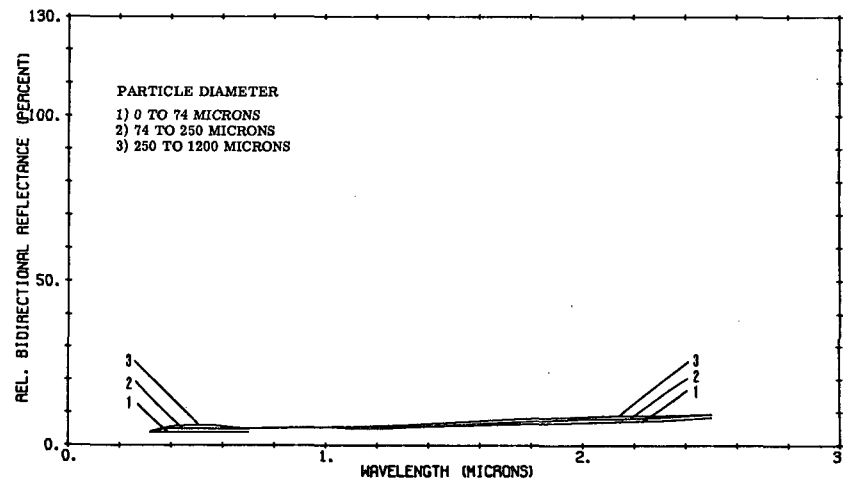
MAGNETITE (FARMINGTON COUNTY, COLORADO)  
1) B09005 043, 2) B09005 044, 3) B09005 045

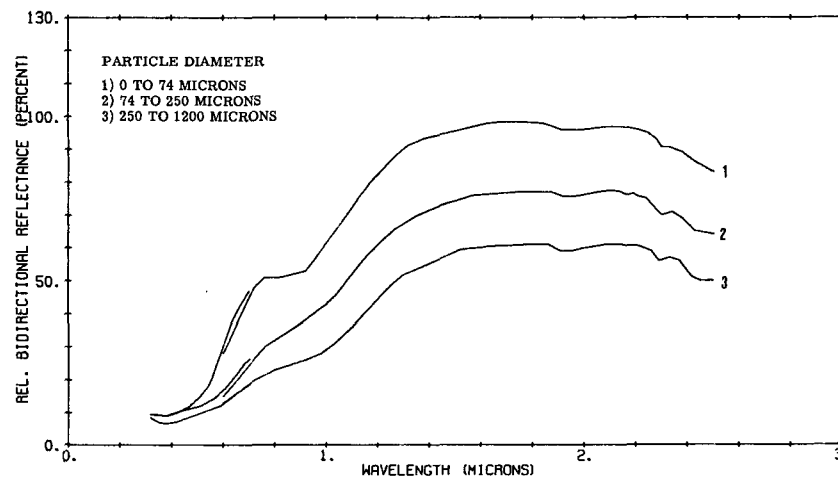
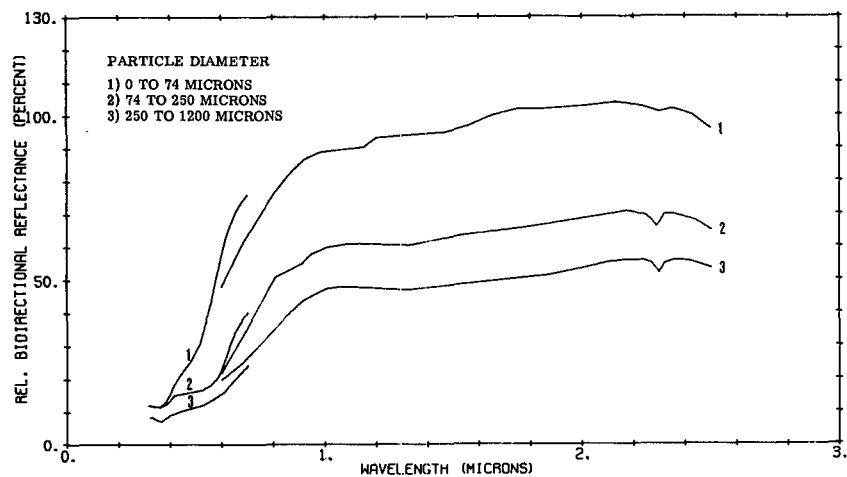
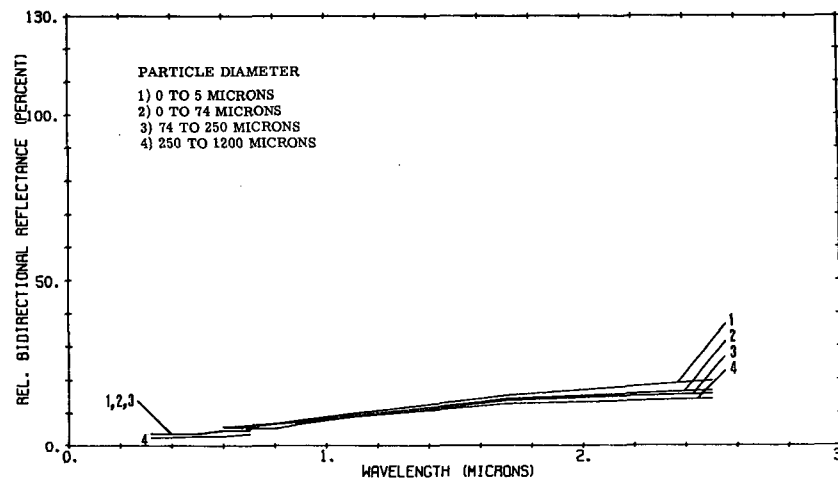
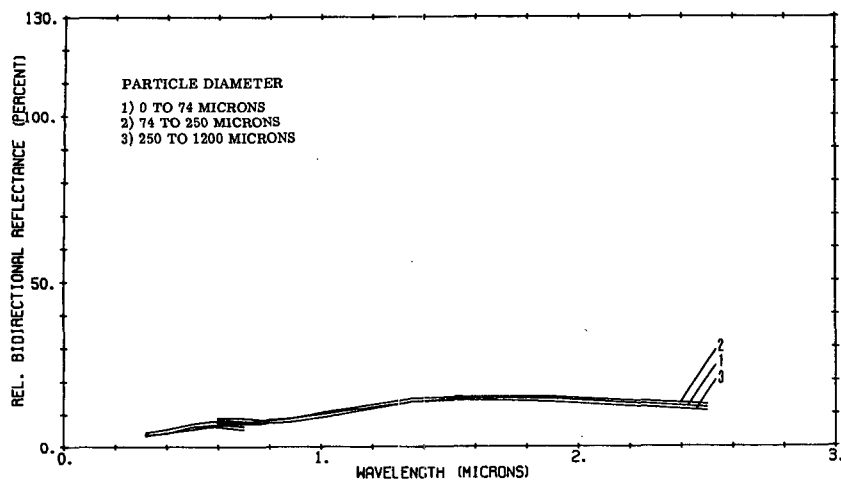


MAGNETITE (ISPING, MICHIGAN)  
1) B09005 046, 2) B09005 047, 3) B09005 048

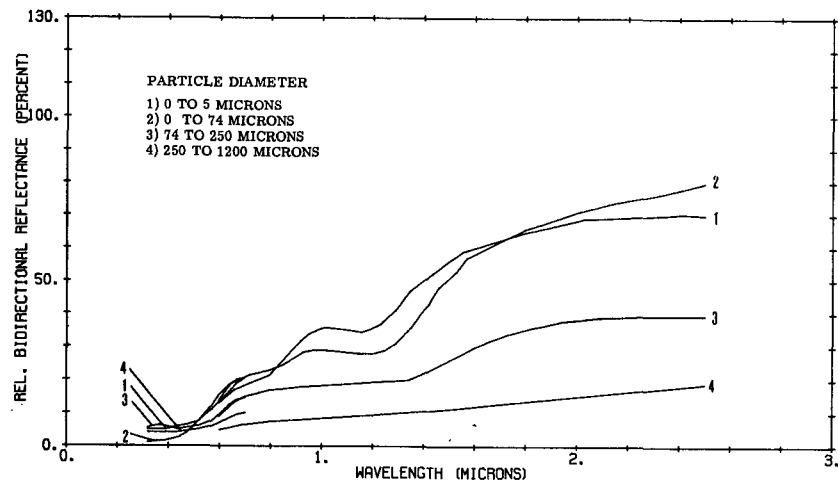


PSILONELANE (MAGDALENA, NEW MEXICO)  
1) B09005 049, 2) B09005 050, 3) B09005 051





ZINCITE-PLUS FRANKLINITE (FRANKLIN, NEW JERSEY)  
1) B09005 065, 2) B09005 066, 3) B09005 067, 4) B09005 068



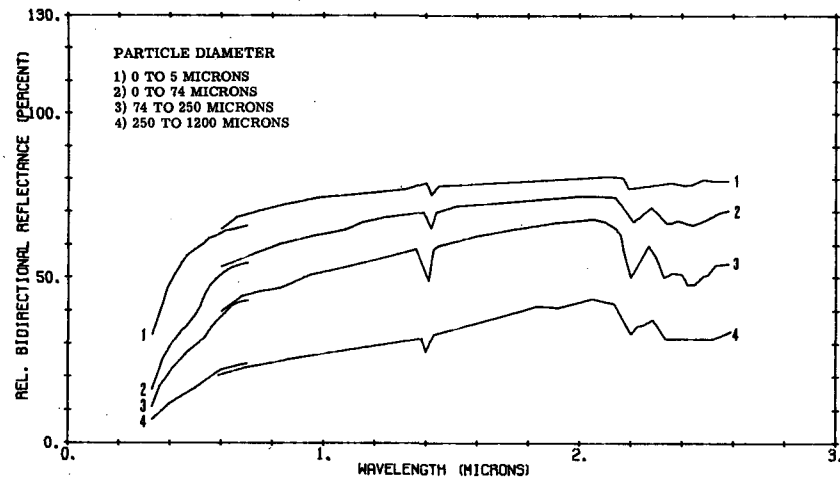
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MINOR SILICATE MINERALS

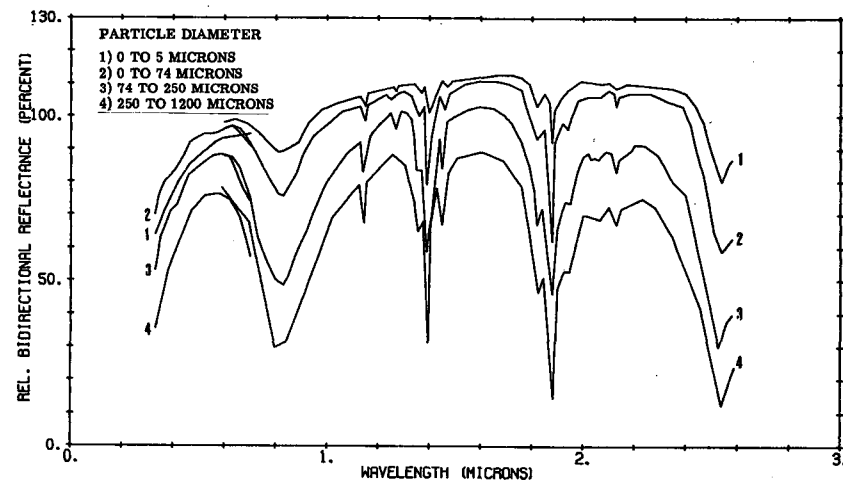
137



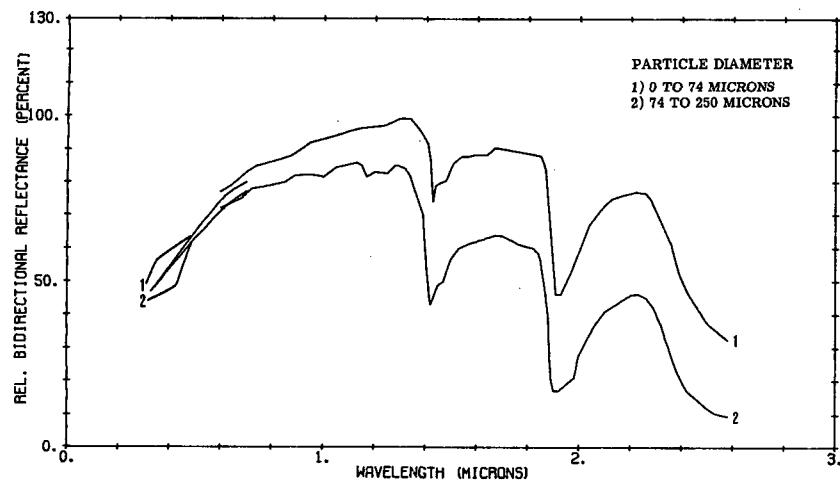
ANDALUSITE (AUSTRALIA)  
1) B09000 029, 2) B09000 030, 3) B09000 031, 4) B09000 032



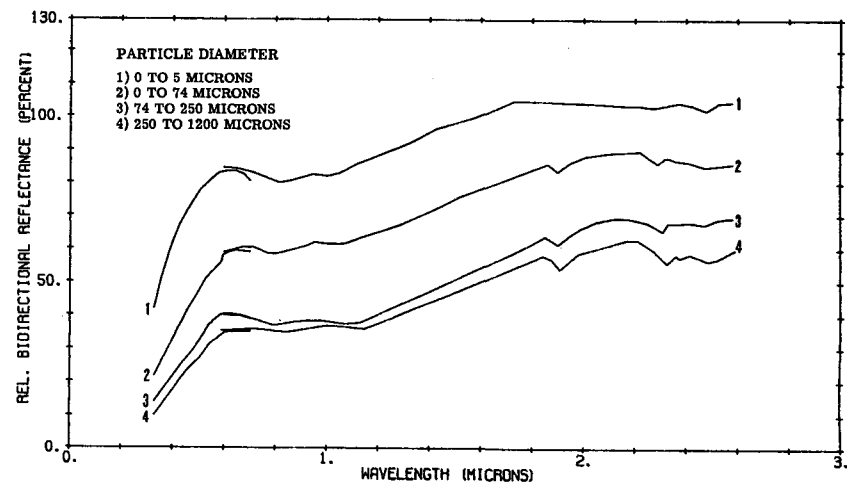
BERYL (MAINE) 1) B09000 038, 2) B09000 037, 3) B09000 039, 4) B09000 040

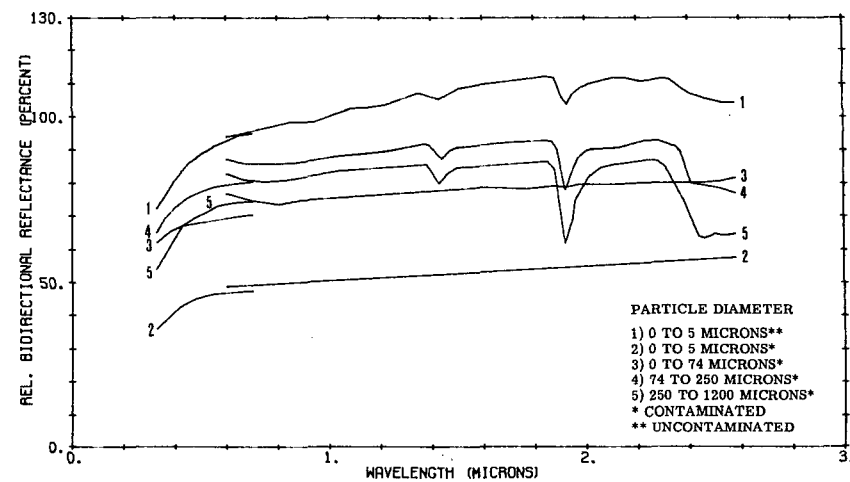
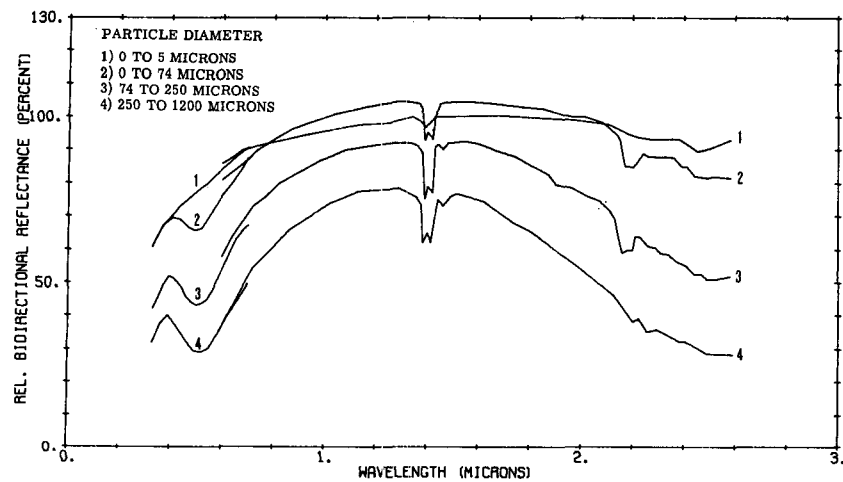


CHARAZITE (COLORADO)  
1) B09000 044, 2) B09000 045



DANBURITE (NEW YORK)  
1) B09000 053, 2) B09000 054, 3) B09000 055, 4) B09000 056





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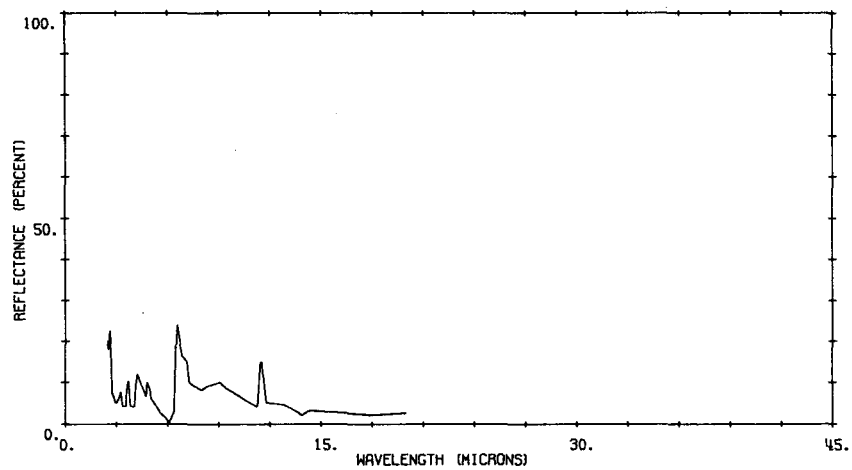
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HYDROTHERMALLY ALTERED ROCKS

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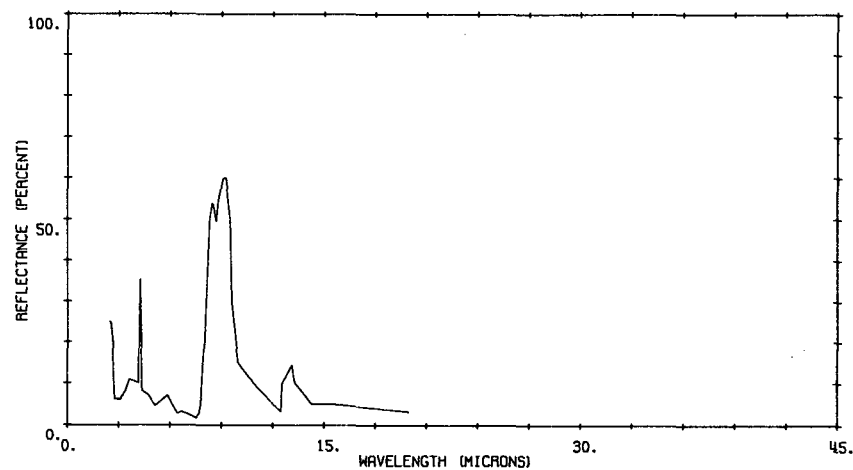
B09006 001

QUARTZ AND RHODOCHROSITE (ANGANGUEO, MICHOACAN, MEXICO).



B09006 004

MINERALIZED BRECCIA (DISTRITO GUANAJUATO, MEXICO).



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B09006 005

QUARTZ PNEUMATOLITICO (BAJA CALIFORNIA, MEXICO).

